A STUDY OF GROWTH OF EXPERIMENTAL MIND DURING ADOLESCENCE

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CERTIFICATE

This is to certify that Miss Madhu Mathur, Student of this College has conducted and completed the present dissertation entitled " GROWTH OF EXTERIMENTAL MIND DURING ADOLESCENCE " under my guidance and supervision.

Her work is genuine and original.

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Madhu Mathur.

MISS MADHU MATHUR

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CHAPTER I

THE PROBLEM AND ITS SIGNIFICANCE

INTRODUCTION

It is difficult, if not impossible, for a person to state the work of Jean Piaget in few words. The biographical aspect of Prof.Jean Piaget, perhaps help us to understand his ingenious work in the field of Education, particularly speaking in the growth of Intellectual mind during adolescent period.

Piaget was born on August 9,1896 in Neuchatel, a french speaking university town in Switzerland. Right, from his early days he was very studious. Interestingly enough, he wrote his first scientific paper at the age of ten for which he was offered the post of a curator at the local Natural History Museum. Piaget was not psychologist in the sense that he obtained his masters degree in the subject of Zoology and doctrol degree at the age of 22 on " Mollusks of Valias "

Possessing a creative mind, Piaget applied his all Zoological and Philosophical knowledge in understanding the Intellectual growth of child during adolescence. He deeply engrossed himself with pupil questions and errors which provided him with missed insights into intellectual development.

About his work, Piaget has said as follows -

" I am a Naturalist and biologist by training interested in epistemological problems without ever having undertaken formal study (nor passed any examination!) in psychology, my most central concern has always been to determine the contributions of the person's activities and the limiting aspects of the object in the process of acquiring knowledge. Fundamentally, it was the wish to resolve this problem using the experimental approach that brought me into the field of developmental psychology. But it follows logically since this point of view is not often held by psychologists in general and even less by child psychologists that those who read my work find themselves confused "

Looking from different angles of thought, Piaget seems somewhat like a seven colour of Vibgyor ,inspite of one Piaget. Like the Nature of waves, it takes time to understand Piaget. Any how, it is sure that a dip in the 'Ganges' of Piaget does affect one's outlook on Educational Problems. The work of Piaget can be co-related with Educational field as the symbiotic relationships between Pea and Nitromonas Bacteria. In the whole Ecosystem balance is a must. The work of Piaget now a days given much emphasis and we cannot separate his work from the Educational field.

The valuable gift given by Jean Piaget to human society, in the form of his beautiful Books, can be summarised as follows .

1.	The Language of Thought of Child	1923
2.	Judgement and Reasoning in the Child	1924
3.	The Child's Conception of the Physical World	1926
4.	The Moral Judgement of the Child	1932
5.	The Origin of Intelligence in Children	1936
6.	The Construction of Reality in the Child	1937
7.	The Child's Conception of Numbers	1941
8.	The Child's Construction of Physical Quantities	1942
9.	Play,Dreams and Imitations in Childhood	1945
10.	The Child's Conception of time	1946
11.	The Child's Conception of Movement and Speed	1946
12.	The Child's Conception of Space	1948
13.	The Psychology of Intelligence	1950
14.	Play,Dreams and Imitation in Childhood	1951
15.	The Origin of Intelligence in Children	1952
16.	Logic and Psychology	1953
17.	The Construction of Reality in the Child	1954
18.	The strategy of Genes	1957
19.	The Growth of Logical Thinking from Childhood to Adolescence	1958
20.	The Child's Conception of Geometry	1960

21. The Early Growth of Logic in the Child	1964
22. Mental Imagery in the Child	1966
23. The Mechanisms of Perception	1969
24. The Psychology of the Child	1969
25. Science of Education and the Psychology of the Child	1969
26. Genetic Epistemology	1970
27. Biology and Knowledge	1971
28. Insights and Illusions of Philosophy	1971
29. Psychology and Epistemology Structuralism	1971
30. Understanding and Causality	1974
31. The Origin of the Idea of Chance in Children	1975
32. The Grasp of Consciousness	1976

It is apparent from his work that Piaget did lot of work in his life time. His work is yet to be evaluated. There are several reasons why his work is being considered of everlasting importance. To quote Vaidya -

(i) " Nature desires that children should remain children before they are men ", echoed Rousseau. Piaget made this clear distinction scientifically, using Methode Clinique, saying thereby, that child is not a little adult.

(ii) He provided the psychological theory of operations which developes in stages. Operations are actions which are internalized and reversible. They can be thus distinguished from simple action or goal directed behaviour.

(iii) There is constant interaction between the organism and the environment out of which develop intellectual structures sequentially. Thought accords with things, actions, and even with itself in the inseparable functioning of organization and adaptation.

(iv) Equally proficient in Zoology, logic and epistemology, he provided rich vocabulary having very deep meanings: adaptation, centration, conflict equilibration, isomorphism, IWRC Group, Operation, reversibility and Scheme of thought etc.,

(v) He brought out clearly the limitations of associationism structuralism, functionalism, behaviourism, and gestaltism. He developed experimental epistemology. Also he did not favour acceleration of thought.

(vi) In the growth of Logical Thinking from Early Childhood to Late Adolescence, he propounded an open research frontier which is yet to be verified as well as tested.

(vii) His theory does not generate sharp hypotheses which can be tested easily by psychometry. The factorial interpretation of his work is just coming up.

It is precisely for this reason, that his work has evoked sharp admiration as well as criticism. He has been described by the critics as follows -

" Discoverer or an unsuspected dimension of truth (Isaac Nathan) ; Mastering at developing the theoretical implications of his work (Hunt) ; Zoologist by training, an epistemologist by vocation and logician by method (B.Inhelder) ; in continuation psychologist by accident (D.M.Hyde); educator by mistake (N.Vaidya) ; an indelible colourizer (J.Flavell); capable of hypothesizing or producing child following any system of logic (K.Lovell); a sort of bulls eye hitter (N.Vaidya) having 'Scant regard for Statistics, Standerized tests and procedures' with speculation thrown in (Eric Lunzer) and Le Patron as lovingly called in Geneva ".

A fundamental idea that underlies all of Piaget's work and consequently is the key to understanding his theory is the concept of mental structure. Basically, mental structures are hypothesized mental blue prints " that guides the organisms behaviour. In the course of intellectual development from infancy to adulthood, these mental structures are constructed and reconstructed within the brain and this construction of mental structure is viewed by Piaget as the fundamental process in intellectual development.

The intellectual progress of the adolescent is intimately interwoven with his receptive and productive powers of Language, be it concerned with his vocabulary, his command of structure or his logical rigour. For this reason, language and other symbolic systems, as in Mathematics and logic, are involved in

higher level thinking. Also, estimates of his intellectual progress are probably best measured through the verbal medium.

A concept will not be acquired if the logical organization of the concept is more complex than the pupils logical operations. The teacher can redesign the logical structure of an entire concept or parts of a concept for a student after the cognitive capabilities of the students has been determined.

OTHER CORRELATED WORK

Sometimes, a partial idea is more important than the scientifically tested idea. Why ? Because it raises more problems than it solves. Something similar has happened to the work of Jean Piaget. Many workers in several countries of world tested his idea and came up with new insights into his work, either confirming or contradicting him. Some of the important publications which arose in vague of his work within the last 25 years or so, are many. Examples are ; Children's Explannation of Natural Phenomena (Oaks N.E.,1947),Experimental Reasonings of Adolescents (Inhelder Barbel,1955), Formal Concrete Thought Processes (Keats J.A.,1955), Recent Studies in Britain Based on the Work of Jean Piaget (Lunzer E.A.1960), The Pupil's Thinking (Peel E.A.1960), The Developmental Psychology of Jean Piaget (Flavell J.1963), Concept Growth and the Education of the Child (Wallace J.C.1965), Problem Solving in Science (Vaidya N.1968), The Piagetian Journey from Mollusks through Moppets to Metaphor (Vaidya N.1981), Piaget and Knowledge (Furth H.G.1968), The Developmental

Theory of Piaget (Karplus R.et al,1969), Cognitive Development and Mathematics Learning (Collis K.F.1974), The Piagetian Research (Mudgil S.et al.1974), The Essential Piaget (Howard E.Grubber et al,1977), Piagetian Psychology (Gebber B.A.Edited, 1977), Cognitive Development in School Years (Floyd Ann,1979), The Psychology of Teaching for Thinking and Creativity (Lawson Anton E.1979), A Mathematical Structures underlying Adolescent Thought (Vaidya N,1981).

PIAGETIAN THEORY

The work of Jean Piaget, provides useful insights into the mental functioning of children. For this valuable work, the Name of Piaget, in the history of developmental psychology will stand, like the body of a giant, head and shoulders above all the others. His work is so fundamental that most papers published in the field of child psychology refer to his view in some way or other. Note, however, that Piaget may not regard himself as an expert developmental psychologist. He is more likely to look upon himself as the founder of a particular branch of psychology, namely genetic epistemology.

Piaget has described the intellectual development of children as a series of consecutive stages which, in turn, are dependent upon each other. Further, he has linked their development to symbolic logic (a branch of mathematics) which has made his work very distinctive.

THE STAGES OF DEVELOPMENT

The development of knowledge is a spontaneous process, tied to the whole process of Embryogenesis. Embryogenesis concerns the development of the body, but it concerns as well the development of the Nervous System and the development of mental functions. In the case of the development of knowledge in children, embryogenesis ends only in adult hood, In other words, development is a process which concernsthe totality of the structures of knowledge.

A " Stage " in this development of intellectual behaviour may be defined as the totality of behaviours similar in function and in dependence on the environment. In Piaget's terms, a stage is identified not by quantitative measurement but by qualitative characteristics. Piaget (1955), Tanner and Inhelder (1956) have attempted to specify the critarial aspects of the stages.

To explain all these developmental stages from early child-hood to late adolescent, Piaget used the term "Operation". According to him - An operation is the essence of knowledge ; it is an interiorized action which modifies the object of knowledge. In other words, it is a set of actions modifying the object, and enabling the knower to get at the structures of the transformation. An operation is never isolated. It is always linked to other operations, and as a result it is always a part of a total structure.

Piaget considers these operational structures as the basis of knowledge and distinguish four main stages of development. Their brief summaries is given as follows ;

S.No.	Name of the Stage	Age	Characteristics and abilities
1.	Sensory Motor Period	0-2 Years	From the Educational point of view, this stage is not much of Educational significance. However, this stage shows following characteristics. - Child is highly dependent upon his parents for satisfaction of his physical need. - Performs only overt activities. - He thinks least about his actions. - He appears to throw whole of himself in physically in the activity. - He is attracted by sound,toudh and other physical stimuli and while crawling,he is on a Voyage of discovery. - Flat pictures do not attract his attention but if he is given a pencil, he can stretch his hand to grasp it.

S.No.	Name of the Stage	Age	Characteristics and Abilities
2.	Pre-Operational Stage	2-7 Years	- He sees things in his own frame of reference. - He can think only one idea at a time. - He uses language in a limited way. Because he feels difficulty in expressing his thoughts. - He can carry on conversation with himself and in this he least cares whether other listen to him or not. - His social interest begins to widen and he tends to become less and less self-centred. - His thinking is governed by the perceptual considerations of the situation. His reasoning is then said to be transductive.
3.	Concrete Operational Period.	7-11 Years	- Child's thinking is tied to the concrete situations. He cannot react to " Abstract Situations " - He just begin to attack Problem Systematically.

S.No.	Name of the Stage	Age	Characteristics and Abilities
			- At the same time, he cannot find mathematical explianations for a given task. - He does not accept hypothetical data. - Reality dominates his thinking and the possibility is subordinated to it. - His attention is no longer fixed on one dimension. (Process of decentering). - At the highest levels of abstract reasoning he tries to explain his enviornment. - Formation of consistent classifications during development of concepts. - Ability to cope with the ordering of similar objects according to size or position.(Process of seriation). - Conservation,irrespective of number, shape etc., is crucial for reasoning at this stage.

S.No.	Name of the Stage	Age	Characteristics and Abilities
4.	Formal Operational Period	11-15 Years	- His thinking is no longer tied to the concrete situations. He imagines and considers all sorts of facts, hypotheses and possibilities. - He develops the ability to reason by Hypotheses. - He goes even to the extent of finding empirical and mathematical proof for his observations. - He attempts problem-solving with abstract considerations of possible solutions. - He use logical analysis and combinational experimentation during problem solving. - Thinking is at its highest level of stage along with Maturation.

In the preceeding pages the Piagetian Stages of development revealed that the process of thinking, start from simple to complex and concrete to abstract. But it may be added that children may not show these stages within the age-ranges specified above, because of differing home and school enviornments. But what Piaget insists is that the sequence of these stages in intellectual development remains the same for all children. It is a grand hypothesis which is yet to be tested.

Piaget believes that there are four factors which explain the development from one set of structures to another, They are - Maturation, Experience, Social-transmission and Equilibration, respectively.

Lastly, in his own life time he set up not only the Geneva school but also a new branch of knowledge called " Experimental Epistemology "; that is how a child forms and applies his ideas right from the moment of origin through childhood, adolescence, Adulthood and old age. Piaget has worked on children upto the age of 18^{+} or so. Before his death, he also advanced the fifth stage of mental development, which is link to individual commitment to carreers and aptitude variations.

From his work, A.Blanchet and other have deduced the finest Educational Principles. Which goes along way in meeting individual differences that is it must permit the child to establish plans to reach distant goals, while leaving him wide open freedom to follow his own routine. This is only possible if we have same vague idea how a child goes about in the bussiness of developing his own partial house of knowledge. The present study tests through some problems how his mind becomes experimental.

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CHAPTER -II

REVIEW OF RELATED LITERATURE

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REVIEW OF RELATED LITERATURE

INTRODUCTION

The work of Jean Piaget is getting world wide attention in all the leading countries of the world. In his famous book on the " Growth of Logical Thinking from early childhood to late adolescence ", he has provided not only several problems but also conjuctures needing experimentation and verification of his ideas under different socio-economic conditions. The Research Frontier hinted at by him in this book is yet to be scratched. To quote the Essential Piaget.

" It is not difficult to grasp the main characteristics of formal stage of development in isolation. But the feel of difficulty is reflected when he suggests certain schemes of thought alongwith their corresponding experiments. If the current status of research in this field is evaluated, one

really draws a blank. The schemes of thought alongwith their experiments as suggested by him are as follows :-

S.No.	Scheme	Experiments
1.	Combinations	Chemical combinations, in a system containing a substance to be coloured; a dye, an inhibitor, and a neutral agent.
2.	Proportionality	Equilibrium on a balance beam where the multiplicative relation between length and weight must be dealt with.
3.	Correlations and Probability	Discovering the relations between a pair of imperfectly correlated variables (hairs and eye colour).
4.	Conservation beyond empirical experience	Conservation of movement in a system containing some friction, i.e., rolling balls on a horizintal plane.
5.	Inversion and reciprocity coordinated in maintenance of equilibrium.	Behaviour of liquid in communicating vessels (equality of water levels, relation between water pushed out of one tube and into the other).
6.	Mechanical equilibrium	Hydraulic press 'a more quantitative version of the proceding.'
7,	Corrdination of two reference systems	Snail moving on moving platform.
8.	Equilibrium of work mechanical proportion	Behaviour of wagon on variably plane counter balanced by variable weight on pulley.

S.No.	Scheme	Experiments
9.	Geometrical Proportionality	Predicting size of shadow cast with objects varying in size and distance, screen and source varying in distance.
10.	Compensation of interacting variables.	Behaviour of balls on rotating problem, relation between weight and distance from centre in determining centrifugal motion.

In the present study, an important variable of intellectual development has been selected for intensive study. Because of the following reasons -

1. Prof.Lovell, Dr.Michel share and others have selected only one problem for their studies. This problem is the simple pendulum problem. In this study on the other hand three problems on stating and testing of hypothesis have been selected.

2. According to Prof.Oppenheirmer it is a business of Science to go wrong. On paraphraging him one can also say that it is also the business of human mind to be deriave in the process of creating novelties. So in this study some questions have been headed which intentionally invire wrong answers too.

3. According to Jean Piaget, the Adolescent mind exhausts all possibilities, so in the study we included 2 problems, namely dight problem and seed problem for testing this hypothesis

4. Lastly, Problem sensitivity is also included as another outside variable.

In this context, hardly, any study has been conducted in India and abroad. So the following studies which are of direct relevance to our study are documented below in the tabular form. A brief summary of the significant discovery is given in the end of this chapter.

Author(s) and year	Title of Study	Main Findings.
Bantista, L.B. 1975	The Relationship between Intellectual levels and achievements.	Formal students are better than concrete students.
Bruner, J.S. Goodnow and Austin, 1962	A Study of Thinking	There are four distinct strategies by which a person may form the given concept.
Canter, L.L. and Herren, J.O. 1978	Concrete and Formal Piagetian stages.	Pupils are unable to learn science concepts at both levels.
Dale, L.G. 1970	The growth of systematic thinking. Replication and analysis of Piaget's First chemical experiment.	Majority of the adolescent pupils do not perform at formal operational level.
Docherty, E.M. 1974	Identifying concrete and formal operational children.	Identification of concrete and formal operational pupils through duster analysis

Author(s) and Year	Title of Study	Main Findings
Dulit,E. 1972	Adolescent Thinking a La Piaget, The Formal Stage.	Formal thoughts can be most easily seen in case of adults, normal adolescents and gifted adolescents.
Farrell,M.A.. 1969	The Formal Stage	Sometimes the expected percentage of formal level decreases and may revert to the lower level of cognitive development.
Ginsburg,M.and Opper,S. 1969	Piagets Theory of Intellectual Development.	There is direct relationship between maturity and concrete operational level of student.
Grewal Avinash 1978	A Study of the Relationship Between theses Testing Ability in Science and Creativity.	There was a significant relationship between creativity and testing of hypothesis.
Higgings,T.A. and Gaite,A.J.H. 1971	Elusiveness of formal operational thought.	At the age of 16, the normal adolescent pupil do not reach the formal level of Thinking.
Heidbreder,E. 1928	Problem solving in children and adults.	1. Reactions and sensitivity to solve problem increased with age. 2. The subjective attitude transformed into objective attitude gradually with increases in age.

Author(s) and Year	Title of Study	Main Findings
		3. The attach of problem is more systemic as the
Howe,A., 1974	Formal Operational thought and the high School Science Curriculum.	1. During adolescence subjects spontaneously react to the problem and using all other things equal scheme.
		2. Formal operational subjects attempt to prove something (control variables) rather than describe them.
Jackson,S. 1965	The growth of Logical Thinking in Normal and Sub-normal Children.	1. Only 50% of the adolescence subjects attain a score representing formal operations on the tasks presented to them.
Joyee,L.K. 1977	A Study of Formal Reasoning in Elementary Education Majors.	1. Stating and Testing of Hypothesis Ability seen in limited students.
		2. Students are incapable to react with the suggested variables in a logical manner.
Karplus and Peterson 1970	Intellectual Development beyond Elementary School *11: Ratio, A Survey.	1. It was found out that 32% of the sub urban group is categorized as using proportional thinking but only 5% of the urban group is so categorized. There is approximate ratio of 1:6.

Author(s) and Year	Title of Study	Main Findings
Kofsky, 1966	A Scalogram Study of Classificatory Development.	Age is an important factor in mastering the number of tasks, but there is no set pattern of mastery in various tasks.
Kohlbery and Gillian, 1971	The Adolescent as a philosopher. The discovery of the self in a post conventional world.	Concrete operational stage is more dominent among normal adolescent pupils than formal operational stage.
Lawson, 1974	Relationship of Concrete and Formal Operational Science Subject matter and the Development Level of Learner.	Concrete and Formal Level Increases, in the sequence Biology, Chemistry and Physics students.
Lawson, A.E. and Renner, J.W. 1976	Teaching for Thinking	More than 50% of the subjects were found to be at concrete level and only 20% at the formal level.
Lawson and Blake, 1976	Concrete and Formal Thinking Abilities in High School Biology students as measured by three separate instruments.	In Piagetian tasks 53% of the students were found at formal level, while 36% at formal level in a test on Biology content and 44% in non-science content examination.
Leela Kansakar 1979	A Study on the Exclusion of Variables during Adolescent.	1. The mean of testing hypothesis increases with Grade and each problem is co-related with each other

Author(s) and Year	Title of Study	Main Findings
		2. There is no significant difference in Intelligence while comparing the top and bottom groups.
Lengel,R.A. and Buell,R.R., 1972	Exclusion of Irrelevant factors(The Pendulum Problem)	1. There is gradual growth in the logical operation "exclusion" and no effect of sex,socio-economic status and I.Q.
Linn and Levine, 1976	Adolescent Reasoning,The Development of The Ability to Control Variables.	1. There is direct relationship between thinking process with age.
		2. Concrete Operational is more than the formal operational subjects.
Lius L.Canta and J.Dudley Harren,1978	Concrete and Formal Riagetian Stages and Science Concept Attainment.	1. Pseudo examples are helpful in under-standing the concrete and formal operations.
		2. Formal operational subjects are better than concrete operational.
Lovell,K. 1961	Follow up study of Inhelders and Reagets.The Growth of Logical Thinking.	The stage concept of Riaget is supported by author, that the pupil of low academic ability do not attain formal thought.
Mealings,R.J. 1961	Some aspects of Problem Solving in Science.	At the Mental age of 16^{+} children are supposed to solve abstract and theoretical problems.

Author(s) and Year	Title of Study	Main Findings
Mecke,G. and Mecke,V. 1971	The Development of Formal thought as shown by explanations of the oscillations of a pendulum. A republication study.	1. Formal Operations used by the subjects. 2. The subject used systematic approach and eliminate the irrelevant variables in Piagets Pendulum Problem.
Mokinnon and Renner 1971	Are College concerned with Intellectual Development.	Majority of the college subjects were found to be at concrete operational level and only 25% at formal operational legel.
Misra,R.M. 1973	Role of Hypothesis in Problem Solving among Grade X Science Students.	There are some difficulties experience by pupils in testing hypothesis difference between top and bottom groups.
Norland and et al, 1974	A Study of Level of Concepts and Formal Reasoning Ability in Adolescence.	Majority of students found to be at concrete operational stage.
Pandey,K.C. 1979	A Study of Problem Solving Ability in Science	20% of formal level and 60% at the concrete level, rest in transition stage.
Peel,E.A. 1960	The Pupils Thinking.	According to Peel, there are found types of thinking,Thematic, Explanatory,Productive and Integrative respectively.

Author(s) and Year	Title of Study	Main Findings
Renner and Stafford, 1972	Teaching Science in the Secondary School.	Among the 220 Adolescents of age 10-12 about 26% are at the concrete level and 34% of formal operational level.
Shayre and Ball,1975	Piagetian Cognitive Development and Achievement in Science.	At .01 level the relationship between formal operational level and achievement is significant.
Sheehan,D. 1970	The Effectiveness of Concrete and Formal Instructional Procedures with Concrete and Formal Operational Students.	The formal operational subjects received the formal instructional procedure are not better than the concrete operational subjects, received concrete instructional procedure.
Vaidya,N. 1964	Problem Solving in Science among certain groups of adolescent children.	1. Stating of hypotheses is given by adolescent pupils but they are not in a position to verify them. 2. Although adolescent pupils solve the problem irrespective of their different I.Q. hance, but they do not exhaust all possibilities.
Vaidya N. 1975	The Growth of Logical Thinking in Science during Adolescent.	1. Contrary to Piagets view adolescent childrens are able to state hypotheses but they do not test t hem.

process of self-regulation or equilibriation.

To put in few words, experience or demonstration is a necessary but not sufficient part of learning, because the child must act on thinks and objects, meaning thereby that action is the basis of all knowledge.

The various studies documented above suggest the following main findings still to be tested in cross-cultural studies -

1. The concrete operational stage is quite dominant among normal adolescent pupils.

2. Whereas the adolescents pupil are in a position to stage hypotheses, they are not in a position to test them. At best they can test one variable or so in most of the case.

3. They attack on problem is seen to increase systematically with increasing grade as well as age.

4. It is possible to identify concrete and formal operational pupils through cluster analysis.

5. The study of Physics need more formal thought than Chemistry and Biology.

6. Mental age and grade are the two important factors than chronological age in concept development.

7. There appears to be significant relationship between scores on formal operational thought on the one hand and achievement as well as creativity on the other.

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CHAPTER-III

PLAN AND PROCEDURE

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PLAN AND PROCEDURE

INTRODUCTION

Through his Ingineous Experiments for which he is famous all over the world, Prof.Jean Piaget developed his own way of Investigating Problems,called the " Methode Clinique" or the critical method of exploration. He also succeeded in establishing rapport with children because while young, he played marbles with young children, his own children also, ofcourse, not excluded. Due to the physical limitations of time it was not possible to use this technique. So the questionmaire method was implied. However, the main objectives of the study remained intact in the Piagetian context. So the present study aims at Investigating the following -

STATEMENT OF THE PROBLEM

In the Introductory pages, we have discussed about the Piagetian Theory, concept of Mental Structure and Thinking Process during adolescence. The schemata of thought increases with age and Maturity from concrete to Formal Operation.

In a broader sense the present study is aimed at studying the manner of the -

" GROWTH OF THE EXPERIMENTAL MIND DURING ADOLESCENCE "

PURPOSE OF THE STUDY

This Investigation was attempted for the following purposes -

(i) To determine the Relationship between stating of hypotheses and achievement in Science.

(ii) To determine the relationship between Testing of Hypotheses and Achievement in Science.

(iii) To determine the relationship between stating of hypotheses and Testing of hypotheses.

(iv) To explore the Hump effect, if encountered incedently.

JUSTIFICATION OF THE PROBLEM

The schemes of thought as propounded by Jean Piaget have been loosly worded, with the possible exception of the scheme of thought ; proportion, very little work has been done in area an scheme of thought during adolescence. For example, very little work has been done on the INRC structure. The same is true of stating and testing hypotheses (Proposition).

These two variables were Examined separately by Prof.N.Vaidya in his book " The Growth of Logical Thinking in Science during Adolescence " . As usual, he also used only one problem namely, the flow of water through a glass-tube. It had always been the concern of Prof.Piaget that a given scheme of thought should be studied in its maximal variation. So study was needed where the scheme of thought relative to the stating and testing of hypotheses across the problem could be studied on the same sample and hence, justification of the problem.

HYPOTHESES

The present study propose the following hypotheses -

(i) There is no significance relationship between the following variables -

a) Total score of stating of hypotheses and achievement in science.

b) Total score of testing of hypotheses and achievement in science.

c) Total score of stating of hypotheses and testing of hypotheses.

d) Total score of digit problem and achievement in science.

e) Total score of magic seed problem and achievement in science.

(ii) There is no significant relationship in the scores on the processes of thought all taken together, problem-wise and total Individual Problem-wise from grade to grade.

(iii) There is no difference between the Top group and Bottom Group on -

a) Stating of hypotheses.

b) Testing of hypotheses.

SAMPLE AND SUBJECT

Altogether 120 students of class VI through Class XI of Demonstration Multipurpose High School, Regional College of Education, Ajmer constituted the sample. 20 students from each class in the following age group 11^{+} to 16^{+} were included.

SELECTION OF TOOLS

The following tools were used, which aimed at testing -

(i) Stating of hypotheses

(ii) Testing of hypotheses

(iii) Some Interesting and Funny Questions.

All the three are in the form of Questionnaire.

BRIEF DESCRIPTION OF TOOLS

(i) Questionnaire No.1 (Stating of hypotheses)

In this questionnaire four problems were given namely :-

(i) The flow of water through a narrow tube in a small beaker.

(ii) The oscillation of a simple pendulum.

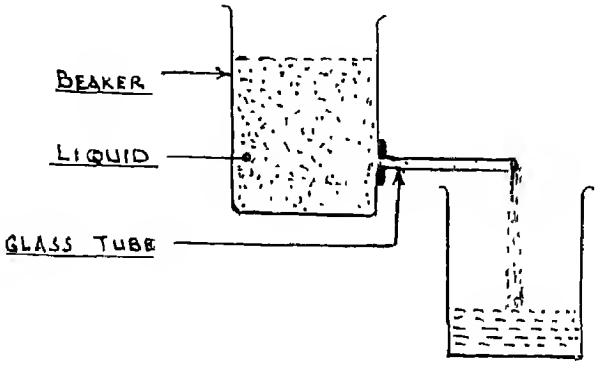
(iii) The movement of target sphere on ramp.

(iv) The magic seed problem.

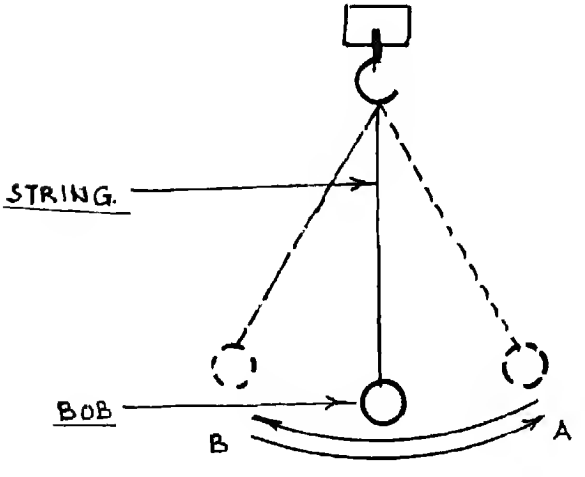
Questionnaire No.2 (Testing of hypotheses)

In this questionnaire only 6 hypotheses of three problems were given for testing. The different hypotheses on each problem were -

THE FLOW OF LIQUID THROUGH A TUBE PROBLEM.



THE SIMPLEPENDULUM PROBLEM.



PROBLEM NO. 1

a) Size of the hole in the glass-tube.

b) Level of the water in larger beaker A.

PROBLEM NO.2

a) Volume of the bob.

b) Weight of the bob.

PROBLEM NO.3

a) The weight of target sphere.

b) The nature of the surface of groove.

Questionnaire No.3 (Some Interesting and Funny Questions)

It includes the following problems -

a. Digit Problem.

b. Cycle Problem.

c. Questions Inviting Wrong Answers.

d. The Magic Seed Problem.

e. The Worm Problem.

(See appendix for all the three questionnaires)

ADMINISTRATION OF QUESTIONNAIRES

The administration was done to the sample selected in their respective classes. The experiments on different problems were set-up and explained to the students by the Investigator herself. The subjects were asked to observe the experiments and write down the different hypotheses on the problem presented. The time taken to state the hypotheses ranged from 30 minutes to 45 minutes.

After the collection of the stating hypotheses questionnaire, testing hypotheses questionnaire, were distributed. Subjects were asked to test the different hypotheses proposed in the problem given. The time taken ranged from 30 minutes to 50 minutes.

The third questionnaire were distributed next day, to the same subjects. Instructions were already given by investigator. This questionnaire was interesting and easy and the time taken ranged from 30 minutes to 40 minutes.

DELIMITATIONS

The present study is delimited with regards to the following -

(i) The pupils of grade VI to XI were considered, ranging within the age limits of 11^{+} to 16^{+}.

(ii) They are of average Socio-economic status.

(iii) They were selected from the English Medium sections of the same school.

The present study is a qualitative study, which attempt to understand, how the minds of children become experimental. So the problem is studied from the developmental point of view rather than the psychometric one. This point of view is being reflected in the next Chapter.

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CHAPTER-IV

QUALITATIVE ANALYSIS

the acquisition of the various individual processes of thought within the thought structure of a given problem under study both within and across the various sub-samples. Lastly, statistical relationship and over-all conceptual interpretations find their place in the succeeding chapters.

QUESTIONNAIRE NO.1

(STATING OF HYPOTHESES)

PROBLEM NO.1

The Problem

The flow of liquid through a tube, this problem presented as follows. There are two beakers A and B, Beaker A contains as much liquid as you wish. It is placed at a higher level than the beaker B. A glass-tube is fixed to the beaker A. The liquid flows from beaker A through the glass-tube into the beaker B.

Name all the factors upon which the quick filling up on the beaker B depends :

1. Size of the beaker A
2.
3.

and so on.

MANNER OF PRESENTATION

The problem was presented as above. The students were said to look at the diagram carefully and name all the factors

upon which the quick filling upon the beaker B depends. For the guidance, one statement is given.

SCORING

Scoring is done by giving one number to each statement. Total number of statement individual pupil wise and gradewise also counted.

ELEMENTS AND AIMS OF THE PROBLEM

The present problem is aimedat investigating the following -

1. To see upto what extent a pupil can state the hypotheses on the given problem.
2. To see upto what extent a pupil can think on present problem. So determine the course of thought process among adolescence.

PRESENTATION OF DATA

TABLE NO.1

Class	VI	VII	VIII	IX	X	XI
Mean	3.8	4.5	8.1	7.8	6.2	7.35
S.D.	.62	2.1	.42	2.57	2.46	.22

SUMMARY OF RESULTS

The problem had too many responses on stating of hypotheses. The main findings on this results shows that -

1. The mean performance increases with grade except in Grade IX and X.
2. The attack of problem is more systematic as we pass through Grade VI to XI.
3. The student while tackling the problem, proceeds from concrete to formal reasoning.
4. Hump-effect is encountered incidently on stating of hypotheses.

PROBLEM NO.2

THE PROBLEM

The simple pendulum problem, presented as follows - It consists of a string whose one end is attached to a hook and the other end to a bob. If you give it a slight push, it moves to and fro sideways. To put in other words, it moves from A to B and back to A. This is called are oscillation (a complete movement). Now name all the possible factors on which one oscillation of any simple pendulum depends -

1. Colour of the string.
2.
3.

and so on.

MANNER OF PRESENTATION

The problem was presented as above. The students were asked to look at the diagram and name all the possible factors, on which one oscillation of any simple pendulum depends. For the guidance one statement is given.

SCORING

Scoring is done simply by giving one marks to each statement. Total number of statement individual pupil-wise and grade-wise also counted.

ELEMENTS AND AIMS OF THE PROBLEM

The present problem is aimed at Investigating the following -

1. To see upto what extent the pupil can state the hypotheses on the given problem.
2. To see thought process among adolescence pupil.

PRESENTATION OF DATA

TABLE NO.2

Class	VI	VII	VIII	IX	X	XI
Mean	4.5	4.6	7.7	8.0	7.5	8.1
S.D.	2.1	1.5	.22	.17	1.2	.13

SUMMARY OF RESULTS

The problem had too many responses on stating of hypotheses. The main findings on this problem shows -

1. The mean performance increases grade-wise except in the grade X on stating of hypotheses.
2. The attach of problem becomes more systematic as we more from grade VI to XI.

PROBLEM NO.3

THE PROBLEM

The Ramp Problem presented as follows -
There is a ramp with a groove along which spheres can roll up and down. A target sphere is placed at the centre of the ramp. When another (rolling) sphere is released from the right (see the diagram), it rolls down the ramp, strikes the target sphere and makes it move up the ramp on the left.

The movement of the target sphere on any ramp depends on the following possible factors -

1. Height of release of the rolling sphere.
2.
3.

and so on.

MANNER OF PRESENTATION

The problem was presented as mentioned above. The students was asked to look at the diagram and name all possible factors, on which the movement of the target sphere on any ramp depends.

SCORING

Scoring done simply by giving one marks to each statement. Also counted the total number of statement individual pupil wise as well as grade-wise.

PRESENTATION OF DATA

TABLE NO.3

Class	VI	VII	VIII	IX	X	XI
Mean	3.1	3.5	7.0	7.0	6.4	7.25
S.D.	.22	.22	.44	.67	.22	.53

SUMMARY OF RESULTS

1. The mean performance increases gradewise except in grade X on ramp problem.
2. The attack of problem becomes more systematic as we move from grade VI to XI.

PROBLEM NO.4

THE PROBLEM

The seed problem is presented as follows - A farmer wishes to grow healthy plants. Name all the possible factors he should consider to make the seeds grow into healthy plants.

1. Healthy seeds.
2.
3.

and so on.

MANNER OF PRESENTATION

The problem was presented as above students were asked to name all the possible factors upon which the Growth of healthy plant depends.

SCORING

Scoring is done by giving one mark to each statement The number of statement individual pupil-wise and grade-wise also counted.

ELEMENTS AND AIMS OF THE PROBLEM

The present problem is aimed at investigating the following -

1. To see upto what extent a pupil can state the hypotheses on the given problem.
2. To see upto what extent a pupil can think on present problem. So determine the course of thought process among adolescence.

PRESENTATION OF DATA

TABLE NO.4

Class	VI	VII	VIII	IX	X	XI
Mean	5.0	6.1	7.2	8.8	6.7	8.9
S.D.	.89	.49	.22	.22	.44	1.7

SUMMARY OF RESULTS

1. The mean performance increases gradewise except in grade X on seed problem.

2. The attack of problem becomes more systematic as we move from grade VI to XI.

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QUESTIONNAIRE NO.2

(TESTING OF HYPOTHESES)

THE PROBLEM

PROBLEM NO.1

THE FLOW OF LIQUID THROUGH A TUBE PROBLEM

Liquid from beaker A flows through a glass tube and collects in the beaker B.

The amount of liquid collected in the beaker B in half an hour, say, depends on the following two factors alone :

1. Size of the hole in the glass tube.
2. Level of water in the beaker A.

Suggest experiments to test these two factors:

1. Size of the hole in the glass tube.

PROBLEM NO.2

THE SIMPLE PENDULUM PROBLEM

The time taken for one oscillation of the pendulum depends upon the following factors:

1. Volume of the bob.
2. Weight of the bob.

Suggest experiments to test these factors.

1. Volume of the bob.

PROBLEM NO.3

THE RAMP PROBLEM

The moving of the target sphere depends on the following factors :

1. The weight of the target sphere.
2. The nature of the surface of the groove.

Suggest experiments to test the above.

1. The Weight of the Target sphere.

MANNER OF PRESENTATION

The problems werepresented as above. Students were ask to look carefully on the diagrams and suggest experiments to test the hypotheses/factors given in problem.

SCORING

Scoring was done by giving one marks to each experiment.

Along with this, scores on immediate reaction is also scored. For this there was three questions presented alongwith the problem. There were three answers, Yes, a bit and No. Marks given to these responses 0 , 1 , 2 respectively.

ELEMENTS AND AIMS OF THE PROBLEM

The present problems are aimed at investigating the following -

1. To see upto what extent a pupil can test the hypotheses by suggesting experiments.

TABLE - 5

Showing Mean Performance and S.D. on various problems of stating of Hypotheses.

S.No.	Name of Problem.	VI		VII		VIII		IX		X		YI	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	S D
1.	The flow of liquid through a tube problem.	3.8	.62	4.5	2.1	8.1	.42	7.8	2.57	6.2	2.46	7.85	.22
2,	Simple pendulum	4.5	2.1	4.6	1.5	7.7	.22	8.0	.17	7.5	1.2	8.1	.13
3	The Ramp Problem.	3.1	.22	3.5	.22	7.0	.44	7.0	.67	6.4	.22	7.25	.53
4	The Seed Problem	5.0	.89	6.1	.49	7.2	.22	8.8	.22	6.7	.44	8.9	1.7

QUESTIONNAIRE NO.2

TESTING OF HYPOTHESES

TABLE- 6

Showing Mean Performance and S.D. on various problems of testing of hypotheses.

1.	The Flow of liquid through a tube problem.	3.35	.22	4.3	.13	5.0	1.11	5.3	.22	5.2	.89	5.5	.22
2.	Simple pendulum prob.	3.4	1.34	4.3	1.34	3.7	.67	4.9	.44	4.9	.22	5.3	.67
3.	Ramp Problem	3.5	2.23	4.0	.44	3.1	.67	4.6	1.78	4.6	1.16	4.9	.44

SUMMARY OF RESULTS - The main findings on these problems shows that -

1. Themean performance increases with grade except in grade X(Problem No.1) Grade VIII (Problem 2+3).
2. The attack of problem is more systematic as we pass through grade VI to X-I .
3. Hump effect is suspected on testing of hypotheses.

QUESTIONNAIRE NO.3

1. (COMBINATORIAL) DIGITAL PROBLEM

THE PROBLEM

You are given four digits 6,7,8 and 9. Form as many digits or figures as you can by using all these digits in any way you like.

(i) 67 (ii) - (iii) (iv) and so on.

PRESENTATION OF THE PROBLEM

The problem was presented as mentioned above. One of the solutions was given, that is, 67. Every pupil was asked to read and re-read the problem until he understood it. It was only stressed that each one of them would make as many combinations as he could think of- without multiplying and dividing the various digits. Only a few pupils from grade VI asked whether they could multiply or divide. They were asked not to do this. No other hints were given.

SCORING

This problem utilises three distinct processes of thought when analysed logically. These are: using two digits at a time (12 possible combinations out of which only one is already supplied), using three digits at a time (24 possible combinations), and using four digits at a time (24 possible combinations). Each suggested combination carried a mark each. So the maximum score carried by this problem theoretically

speaking is 12+24+24 = 60 marks , a very large figure. But for convenience, two digit, three digit and four digit combination were treated separately.

ELEMENTS AND AIMS OF THE PROBLEM

On its very surface, this problem is very simple because it deals with four small individual numbers, lying between 5 and 10. It involves on the part of pupils seeing the individual number in isolation and in relation to the other numbers in all possible combinations, that is, in sets of two, three and four numbers giving in all sixty different combinations. It is at its best a simple modification of Piaget's experimental problem on combinations of coloured and colourless chemical bodies in which the beakers have been replaced by members, a more familiar situation to children. Piaget and Inhelder say :

" The formation of propositional logic which itself marks the appearance of formal thought depends upon the establishment of combinational system..... The structured whole depends on this combinatorial which is manifested in the subjects potential ability to link a set of base associations or correspondence with each other in all possible ways to draw from them the relationship of implication, disjunction, exclusion. (7) ".

In this context, this problem is aimed at investigating the following -

(a) Up to what extent can they structure this problem ?

(b) Upto what extent can they exhaust all the possible combinations within a given and across allied categories which are supposed to exist logically ?

(c) What are the most difficult combinations judged by the pupils ?

(d) What errors do they make while tackling this problem?

(e) Taking on overall view, upto what extent are the various categories filled in ?

PRESENTATION OF DATA

Mean and Standard deviations grade-wise for the various sub-samples.

TABLE - 7

	Using 2-digits at a time.					
S.No.	VI	VII	VIII	IX	X	XI
Mean	8.6	17.4	15.5	8.6	18.5	20.0
S.D.	1.52	2.94	2.52	1.14	3.21	3.57
	Using 3-digits at a time					
Mean	.60	3.1	4.7	3.1	6.4	9.2
S.D.	4.2	3.35	3.99	3.57	7.78	8.39
	Using 4-digits at a time					
Mean	6.2	3.6	4.0	8.6	5.2	4.0
S.D.	8.27	6.71	4.83	3.39	5.81	2.12

SUMMARY OF RESULTS

This problem had too many responses which presented its own characteristic problems of tabulation. The main results on this problem indicate -

1. Mean performance increases with grade although there are some exceptions.
2. Except a few fluctuations, especially due to polarisation in thinking, each combination is mastered increasingly as the pupils move into higher grades.
3. Single aspect character or polarisation of thinking is noticed which appears to be a temporary affair for it completely disappears in the closing grades . Hump effect is suspected.
4. Two-digit categorey is filled in first and the three-digit and four-digit categories are filled in later on, the extent of their getting filled in being: 65%, 20% and 15%. The illustrated step appears to have assisted pupils in filling in the first category.
5. Contrary to Piaget, adolescent pupils commit a large number of arbitrary errors when there is failure to accept the main demands of the problem. Whereas there is general decline with increasing grade, pupils are attracted more by extraneous considerations. If actual combinations are counted physically which have no business to be there for they are based upon digits not given in the problem, it appears that these errors appear, not only within a given grade but also across grades. These errors are, except occasional

fluctuations here and there, not blind but manifest distinct modes of reasoning.

6. Several interesting types of errors appear. First, if the supplied combination is again given which it is not necessary to give, and if it is regarded as error, it undergoes a hump. Secondly, if number of errors committed on three categories are counted gradewise, these errors also under go a hump. Thirdly-, the number of pupils failing to give a single combination on two digits, three digits and four digits combination again undergoes a hump.

7. It is of interest to mention in passing about the relationship of this problem to other variables. At the usual level of significance, it correlates significantly and positively with all the problems as well as the schemes of thought and score obtained in the science subject.

8. The following combinations were found to be quite difficult.:

(i) 97,86,87,96 on two digit combinations given by 50%,40%,45% and 40% of the pupils.

(ii) 796,786,789,869,879,798 on three digit combinations were given by 12%,11%,13% of the pupils.

(iii) 9687,9867,8976,9768,8796,8976 on four digit combinations were given by 14%,13%,14.5%,11% of the pupils.

PROBLEM - 2

FORMULATING QUESTIONS PROBLEM

THE PROBLEM

Frame as many questions as you can on CYCLE whose answers you do not know. In other words, if you know the answer to the question that comes to your mind, please do not write it down. Now start writing these questions only, whose answers you do not know.

MANNER OF PRESENTATION

Each pupil was asked to read and re-read the above question. He was allowed to seek any clarification within the statement of the problem. There was no interruption once he started.

SCORING

One mark for each acceptable question. Here only those questions whose answers were too obvious were rejected straightaway from scoring.

ELEMENTS AND AIMS OF THE PROBLEM

In the words of John Holt - " We encourage children to act stupidly, not only by scoring and confusing them but by boring them, by filling up their days with dull, repetitive tasks that make little or no claim on their attention or demands on their intelligence ".

He further adds that most of the time they are engaged on dull tasks, result being that they hardly make use of their talents and tools because before long they are deeply settled in a nut of un-intelligent behaviour from which most of them could not escape even if they wanted .

At the same time, it is still believed that under certain conditions, children can be made to think and raise questions. They can as well as guided to answer them.

The results of these studies indicated that children ask all sort of questions which stem practically from all the significant areas of human living. They naturally pick-up much information incidentlly from their immediate enviornment in which they live and acquire partial facts and concepts. In this process of formulating facts and concepts about the problem of cycle they think in their own specific way and try to identify and solve the problem according to their mental growth.

The main purpose for including this problem in this study was to check the hypotheses whether ability to formulate problems quantitatively as well as qualitatively was related to other schemes of thought included in this study.

In short, this problem aims at investigating the following -

a) What acceptable questions/problems are asked by the adolescent pupils ?

b) What is their performance in formulating problematic situations from grade to grade ?

PRESENTATION OF DATA

TABLE - 8

Class	VI	VII	VIII	IX	X	XI
Mean	2.45	2.72	3.12	3.91	4.31	7.52
S.D.	1.78	3.19	.44	1.56	1.11	2.13

SUMMARY OF RESULTS

1. The problem on cycle shows an increasing trend of mean performance with the grade. This is in accordance to the expected findings on Piagetian Task.
2. This thought provoking problem put the child in new thinking situation in which there was no ceiling on the number of questions to be formulated qualitatively as well as quantitatively.
3. To stress the main reason for including a problem of this type was to judge pupil sensitivity to self-generated problematic situations, a matter of individual judgement.

On further analysis the various responses, which were obviously rejected. The list of some accepted and rejected questions are provided as follows :-

ILLUSTRATION OF SOME REJECTED QUESTIONS

1. The cycle has two wheels.
2. What is kerb cycle ?
3. Which is the best cycle in the world ?

4. How many company made cycle ?
5. What oil we gave to it ?
6. What is the size of cycle ?
7. What care should be taken in Rainy season ?
8. Why cycle move on road, and not in sky ?
9. Why cycle has not a head light ?
10. How many colours of the cycle ?

(b) ILLUSTRATION OF SOME ACCEPTED QUESTIONS

1. How cycle brakes work ?
2. How many times the wheels has gone round ?
3. What is the thickness of ball-bearing ?
4. How many nuts are used in chain ?
5. Why brack-fails suddenly during cycling ?
6. What is the use of mudguards in the tyre ?
7. Why there is puncture?
8. What is the literal meaning of cycle ?
9. Why the cycle not move in opposite side on paddling in the same direction?
10. Why does the tube of a cycle brust or suffer puncture due to very hot weather or heavy sunlight ?

TABLE - 9

Showing scores on rejected questions.

S.No.	VI	VII	VIII	IX	X	XI
Scores	12	18	8	20	11	17
Means	.6	.9	.4	1.0	.5	.8

PROBLEM NO.3

(QUESTIONS INVITING WRONG ANSWERS)

THE PROBLEM

Read the questions given below and then answer them carefully.

S.No.	Question	Scoring Key	Maximum Score
1.	A blind man with one eye can see upto a distance of 100 ft. How for can he see with two eyes ?	0 — 200 ft 1 — 100 ft 2 — 0 ft	2
2.	A cow is standing beside a tree. A rope or cord of 1 meter is tied around her neck. Tell how for from the tree she can go for eating grass.	0 - Any other answer 1 - Can go any where.	1
3.	Suppose a donkey has two horns. How many horns in all have eight donkey ?	0- No horns 1 - If then statement.	1
4.	A stick is 10 inches long.It is cut an inch per minute. How much time will it take for it to be cut into 1 inch pieces?	0- 10 minutes or any other time. 1- 9 minutes.	1
5.	How many corners of the handkerchief are left if you cut off one of its corners with the help of a pair of scissors?	0- any other answer 1 - 5 corner.	1

S.No.	Question	Scoring Key	Maximum Score
6.	Suppose some ducks are swimming under a bridge in a single line. Two ducks in front, Two in the middle and the behind. How many ducks are there in all ? The number of ducks should be as small as possible that is, the smallest.	0- any other combination. 1- Four ducks.	1

Maximum Score(7)

MANNER OF PRESENTATION

These questions were presented as mentioned above. No other hints were given. All pupils were, however, allowed to read and re-read the various questions. Responses strictly invluenced by the content of the question carried 0 marks.

ELEMENTS AND AIMS OF THE PROBLEM

As suggested by Koffka and also out of sheet interest, this problem containing 6 funny items was included in this problem . These intentionally invited wrong answers especially from those whose general grasp over the situation was poor. For this reason this category was called: Failure to grasp the essence of the problem in which higher score should the better grasp on the problem (schemes of thought) while solving these problems student take extra care. They infact corrected their previous responses as they went along solving them. This problem also lessened their boredom, if any,

because it evoked, as they put it, unusual sort of thinking little subject to usual four fundamental rules of arithmetic for their mechanical application invariably gave wrong answers.

PRESENTATION OF DATA

TABLE - 10

Class	VI	VII	VIII	IX	X	XI
Mean	1.15	1.45	1.65	2.15	2.55	4.5
S.D.	.22	.22	.22	.22	.22	2.13

SUMMARY OF RESULT

1. The gradewise means increases with age which show that pupils grasp on the problem, as a whole increases as they move into higher grades.
2. The adolescent pupils thinks, hard while solving even questions needing restricted throught. This is confirmed by several errors unexpectedly appear when they fail to accept the problem. To concretise, several ideas complete hard when their thinking is influenced wholly by the content of the problem. But there is one constraint here, that is, when they suspect something fishy, they become extra careful in suggesting or reconsidering a well considered answer which could be quite mathematical (and even still go wrong) Examples are -

1. A blind man can not see, the question is wrong.

2. How many horns have eight donkeys ? It has puzzled many. It has attracted four different responses. First, eight donkeys have no horns because a donkey has no horns, the argument being : why should I suppose wrong thing when I can physically see ? Secondly, the answer is 2 because only one donkey has two horns and remaining seven has no horns. Thirdly the answer is 8 because the number of donkeys in question is 8, a jolly good example of equality of opportunity. Fourthly, the answer is, because a donkey has a horn. It does not matter whether it is one or two.

3. How many ducks are swimming under the bridge ? If they see eight, they cannot see six. If they see six, they cannot see four (the correct answer).

4. How for can the cow go ? Several interesting answers have appeared on this question. The answer ranged from $\frac{3}{4}$ meter, 1 meter, 2 meter, $\frac{1}{2}$ meter, πr^2 respectively and they give their own views in supporting their answers.

5. Majority of adolescent pupil cannot suspend their judgement when they tackle a defective or incomplete question, a question whose answer is not available for the needed information is missing within the question itself. This again shows that majority of students influenced more by the content rather than form of the question.

6. As expected, this problem correlate positively and significantly with all the remaining problems as well as schemes of thought. It also correlate significantly with grade as well as intelligence. It correlates significantly but negatigely with felt difficult of the problem (due to reversible scoring). It is interesting to note that it corelates insignificantly with understanding of the problem, confidence in the problem and interest in the problem.

PROBLEM 4

MAGIC SEED PROBLEM

THE PROBLEM

A farmer had some magic seeds. He did not know how to grow them into healthy plants. The only things he knows was that their growth depended upon the following three factors -

1. Water 2. Fertilizer 3. Sunlight.

Your job is to plan as many experiments as you can possibly think of. Please see that no factor or part of the factor is missed by you.

PRESENTATION OF THE PROBLEM

The problem was presented as mentioned above. One of the solution was given that is, High (water),High (fertilizer), High (sunlight). Students are asked to write other possible experiments, as far as they could think . They are also allowed to use abbrivation of the word High (H), Medium (M) and Low (L). No other hints were given.

SCORING

It is combinatorial problem like the digit problem. So the scoring procedure is similar to the previous one. That is each combination carried a mark each. In this case there are total 27 combination possible, and hence maximum score is 27. Resting points was also counted for the same problem.

ELEMENTS AND AIMS OF THE PROBLEM

On its very surface, this problem is very simple because it deals with three factors, namely water,fertilizer and sunlight. It involves on the part of pupils make the different combination of these factor, varying their quantity as high, low and medium to make the seeds grow into healthy plants. It is at its best a simple modification of Piaget's experimental problem on combinations of coloured and colourless chemical bodies in which the beakers have been replaced by numbers, a more familiar situation to children.

In this context, this problem is aimed at investigating the following -

(a) upto what extent can they structure this problem ?

(b) upto what extent can they exhaust all the possible combinations within a given and across allied categories which are supposed to exist logically ?

(c) what are the most difficult combinations judged by the pupils ?

(d) what errors do they make while tackling this problem ?

(e) taking on overall view, upto what extent are the various categories filled in ?

PRESENTATION OF DATA

TABLE -11

Class	VI	VII	VIII	IX	X	XI
Mean	10.3	14.25	19.15	18.15	22.7	23.65
S.D.	1.31	1.11	.67	.67	3.5	5.8

SUMMARY OF RESULTS

This problem had too many responses which presented its own characteristics problems of tabulation. The main results on this problem indicate -

1. Mean performance increases with grade except in grade IX.

2. Single aspect character or polarisation in thinking is noticed which appears to be a temporary affair for it completely disappears in the closing grades. Hump effect is suspected.

3. Contrary to Piaget, adolescent pupils in this group are not in a position to exhaust all the possibilities. Except in few cases in the closing grades, systematic attack on the problem is hardly perceptible.

4. Each combination is mastered increasingly as the pupils move into higher grades.

5. Contrary to Piaget, adolescent pupils commit a large number of arbitrary errors when there is failure to accept the main demands of the problem.

6. Several intersting types of errors appear. First, if the supplied combination is again given which is not necessary to give, these errors all called resting points. If it is regarded as error, it undergoes a hump. Contrary to Piaget mean performance of errors (resting points) increases with grade, the data shown as follows -

TABLE - 12

Showing Resting Points (Magic Seed Problem) Grade-wise.

S.No.	VI	VII	VIII	IX	X	XI
Mean	.6	1.8	5.5	3.8	3.5	4.4

PROBLEM NO.5

THE WORMS PROBLEM

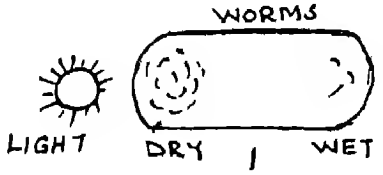
THE PROBLEM

To solve the problem of movement of worms in light and moisture, experiments was done by placing 20 worms in the centre of each of the four glass boxes under different conditions of light and moisture. Light was provided by the electric bulb to the required part of the box. The data are shown in the four diagrams given below. Your problem is to have a close look at each of these diagrams and reach a suitable conclusion. You are free to suggest any other experiment, if it might help to solve the problem clearly.

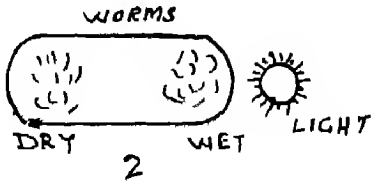
Look at the diagrams carefully,

Be sure to pay attention to each variable of the given figures.

1. What do you concluded from the diagrams (1) and (3).



1



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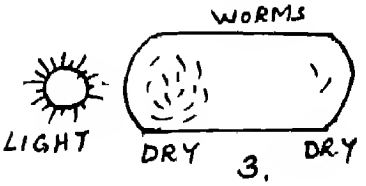
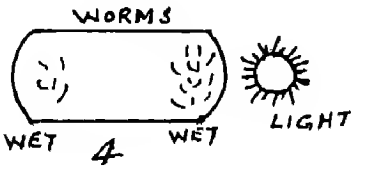


3.



4

2. What do you concluded from the diagram (2) and (4).

3. Is any other experiment necessary ? If yes, suggest the experiment with diagram.

PRESENTATION OF PROBLEM

The problem was presented as mentioned above. The students were asked to look at each of these diagrams and reach a suitable conclusion. They are free to suggest any other experiment, if necessary to explain the solution of problem.

SCORING

Scoring is done simply by alloting a number to each problem and 3 marks for the third question, for suggesting any new experiment.

ELEMENTS AND AIMS OF THE PROBLEM

The worm problem is actually a part of testing of hypotheses. In this, problem we present certain situations before the students to test the movement of worms. The students were asked to test the present situation and suggest experiment, for explaining their answers.

The aim of the present problem is thus to know that how for a child can test the hypotheses and suggest experiment according to his own thinking process.

In this context, this problem is aimed at investigating the following -

CHAPTER-V

STATISTICAL ANALYSIS AND INTERPRETATION OF DATA

CHAPTER V

STATISTICAL ANALYSIS AND INTERPRETATION OF DATA

INTRODUCTION

In the present study data were collected in respect of 120 pupils of grade VI to XI and ranging in age from 11^{+} to 16^{+} on stating of hypotheses and testing of hypotheses in science along with achievement in Science, Mathematics and English. Means, Standard deviations, Correlation, Analysis of variance and t-values were computed. These statistics are presented, with their interpretation as follows -

TABLE NO.1

GRADEWISE MEAN PERFORMANCE ON FOUR PROBLEMS IN STATING HYPOTHESES

S.No.	Name of Problem.	Mean Performance					
		VI	VII	VIII	IX	X	XI
1.	The Flow of Liquid through a tube.	3.8	4.5	8.1	7.8	6.2	7.85
2.	Simple pendulum	4.5	4.6	7.7	8.0	7.5	8.1
3.	Ramp Problem	3.1	3.5	7.0	7.0	6.4	7.25
4.	Seed Problem	5.0	6.1	7.2	8.8	6.7	8.9

TABLE NO.2

GRADEWISE MEAN PERFORMANCE ON THREE PROBLEMS IN TESTING OF HYPOTHESES

S.No.	Name of Problem	Mean Performance					
		VI	VII	VIII	IX	X	XI
1.	The Flow of liquid through a tube	3.35	4.3	5.0	5.3	5.2	5.5
2.	Simple pendulum	3.4	4.3	3.7	4.9	4.9	5.3
3.	Ramp Problem	3.5	4.0	3.1	4.6	4.6	4.9

TABLE NO.3

GRADEWISE MEAN PERFORMANCE ON SOME INTERESTING AND FUNNY QUESTIONS

S.No.	Name of Problem	Mean Performance					
		VI	VII	VIII	IX	X	XI
1.	Digit Problem (using 2-digit at a time)	8.6	17.4	15.5	8.6	18.5	20.0
2.	Digit Problem (using 3-digit at a time)	.60	3.1	4.7	3.1	6.4	9.2
3.	Digit Problem (using 4-digit at a time)	6.2	3.6	4.0	8.6	5.2	4.0
4.	Cycle Problem	2.45	2.72	3.12	3.91	4.31	7.52
5.	Magic Seed	10.3	14.25	19.15	18.15	22.7	23.65
6.	Worm Problem	3.9	4.5	4.2	4.4	5.0	4.75
7.	Inviting wrong answers	3.1	3.6	3.8	3.0	3.1	1.8

TABLE NO.4

GRADEWISE S.D. ON STATING,TESTING AND SOME INTERESTING AND FUNNY QUESTIONS

S.No.	Name of Problem	S.D.Values					
	(Stating of Hypotheses)	VI	VII	VIII	IX	X	XI
1.	Flow of liquid	.62	2.1	.42	2.5	2.4	.22
2.	Simple pendulum	2.1	1.5	.22	.17	1.2	.13
3.	Ramp Problem	.22	.22	.44	.67	.22	.53
4.	Seed Problem	.89	.49	.22	.22	.44	1.7
	(Testing of Hypotheses)						
5.	Flow of liquid	.22	.13	1.1	.22	.89	.22
6.	Simple pendulum	1.3	1.3	.67	.44	.22	.67
7.	Ramp Problem (Some interesting and funny questions)	2.2	.44	.67	1.7	1.1	.44
8.	Digit Problem (using 2-digit)	1.52	2.9	2.5	1.1	3.2	3.5
9.	Digit Problem (using 3-digit)	4.2	3.3	3.9	3.5	7.7	8.3
10.	Digit Problem (using 4-digit)	8.2	6,7	4.8	3.3	5.8	2.1
11.	Cycle Problem	1.78	3.19	.44	1.56	1.11	2.13
12.	Magic Seed	1.3	1.1	.67	.67	3.5	5.8
13.	Worm Problem	.44	1.34	.89	2.1	.44	.22
14.	Inviting wrong answers	.22	.22	.22	.22	.22	2.13

TABLE NO.5

PRESENTATION OF CONSOLIDATED DATA ON SELECTED PROBLEM SHOWING CORRELATION AMONG THEM

S.No.	Correlation between	VI	VII	VIII	IX	X	XI
1.	Stating of hypotheses and achievement in Science.	+.932	+.967	+.938	+.886	+.218	+.257
2.	Testing of hypotheses and achievement in Science	+.96	+.957	+.982	+.967	+.908	+.703
3.	Testing and Stating of Hypotheses.	+.994	+.990	+.988	+.947	+.927	+.941
4.	Digit Problem and achievement in Science.	+.920	+.884	+.908	+.884	+.975	+.929
5.	Magic Seed and achievement in Science.	+.915	+.976	+.937	+.893	+.945	+.927

TABLE NO.6

SHOWING CORRELATION VALUE BETWEEN TOP AND BOTTOM GROUP

S.No.	Correlation Value	Schemes of Thought	
		Stating of hypotheses	Testing of hypothes
1.		+.853	+.875

TABLE NO.7

PRESENTATION OF CONSOLIDATED DATA SHOWING t-values.

S.No. Class	Stating of hypotheses		Testing of hypotheses		Digit Problem.	
	t - Value	Signifi-cant	t - Value	Signifi-cant	t - Value	Signifi-cant
1. VI - VII	.796	Non-Signifi-cant	1.31	Non-Signifi-cant	1.24	Non-Signific
2. VII-VIII	2.97	Signifi-cant(.05)	3.83	Signifi-cant(.05)	.171	Non-Significa
3. VIII-IX	.931	Non-Signifi-cant.	4.85	Signifi-cant(.05)	.033	Non-Significa
4. IX-X	1.716	Signifi-cant(.01)	.067	Non-significant	.891	Non-Significa
5. X-XI	2.55	Signifi-cant(.05)	.929	Non-Significant	.179	Non-Significa

at .01 level = 1.71
at .05 level = 2.81

TABLE NO.8

PRESENTATION OF CONSOLIDATED DATA SHOWING F-ratio

S.No. Class	VI(11)	VII(12)	VIII(13)	IX(14)	X(15)	XI(16
1. F-ratio	15.48	16.68	20.86	9.62	5.06	5.2
2. Signifi-cant	(Highly Significant)	(Highly Signifi-cant)	(Highly Signifi-cant)	(Signi-ficant)	(Signi-ficant)	(Sign fican

* All are significant.
at .05 level of significanre = 2.29
at .01 level of significance = 3.17

INTERPRETATION OF TABLE I,II AND III

Table I,II and III shows the gradewise Mean Performance on problems regarding stating of hypotheses. Testing of hypotheses and some interesting problems. The data on various problems shows an increasing trend, with grade and age, which is an expected finding according to the Pigetian context.

The data on further analysis shows a slight fluctuation which is seen in grade VIII,IX and XI. This phenomenon occur perhaps due to the divergent and dispersed thinking of children at the adolescent a stage. Hump effect encountered incidently further shows this fluctuations. (Reference Chapter-VI).

INTERPRETATION FROM TABLE IV

Table IV shows the S.D.values, gradewise on stating of hypotheses, testing of hypotheses and some interesting and funny questions. Table shows the heterogenous distribution of S.D.values. It decreases as the grade increases in most of the cases. In problem inviting wrong answers the S.D.value remains some for all the grades,which shows the homogeneous distribution of the S.D.values,.In the digit problem, the S.D.value increases with grade and similar to that of the Piagetian Theory.

INTERPRETATION OF TABLE V AND VI

Table V presenting consolidated data on correlation between various variables including stating of hypotheses. Testing of hypotheses, achievement in science, Magic seed problem, digit problem and between top and bottom group.

The data shows the positive correlation between various variables . This means that all the variables are interdependent. The child scores highest marks in stating of hypotheses as well as in testing of hypotheses. This is an expected finding.

INTERPRETATION OF TABLE VI

Table VI presents consolidated data showing t-values for stating at hypotheses and testing of hypotheses, and digit problem. To determine the t-value, mean differences for two classes computed as between VI-VII, VII-VIII, VIII-IX, IX-X, and X-XI.

The t-values found to be non-significant for the digit problem while on the other hand it was found to be significant at stating of hypotheses for classes VII-VIII, IX-X, and X-XI.

On testing of hypotheses t-values were found to be significant for the classes VII-VIII and VIII-IX while it was non-significant for the other classes.

INTERPRETATION OF TABLE VII

Table VII presents the consolidated data on analysis of variance by computing the F-ratio. The F-ratio for each class was found to be significant, at .01 level and .05 level of significance.

It is interesting to note that as the grade and age increases the F-ratio was found to be highly significant as data presented in class VI(11), VII(12) and VIII(13) show. A while on the other hand the data presented for grade IX, X and XI, ranging age from 14^{+} to 16^{+}, the F-ratio is significant but not as much as shown by former three classes. This finding is according to piagetian context, showing that at the age of 10^{+} to 12^{+} the thought processes in the child is at its peak.

EDUCATIONAL IMPLICATION -

Although Piaget did lot of work during his life time on growth of experimental mind during various stages of childhood, adolescence and adulthood, he stressed less on the Educational Implication of his vast work. He used to say frequently, " I am not interested in psychology, education and Children ". According to him -

(i) Children learn through self-activity.

(ii) Children learn from each other in group situations.

(iii) Teachers are completely mistaken if they think that they can give an idea to their pupils and that pupils have completely mastered the concept, if they, give the right answer to the teachers question.

(iv) Children can accommodate knowledge through thinking, actions of things, objects and ideas that they assimilate.

So he emphasized education for understanding through exploration and invention of operation. Hence, it seems difficult to pinpoint the educational implications, of Prof. Jean Piaget. As Piaget give much stressed on child- centred method and believe in learning by doing, the following are the two major implications of his geneous work as -

1. Children should be allowed abundently the processes rather than the products of thought. Use of materials and experiments can be very handy. Even they do not solve the problem because the concepts underlying proportion, are difficult to acquire. The stating of hypotheses and testing of hypotheses as propounded by Piaget is another example which ought to have been mastered within the pupils of the age groups selected in the study.

2. The second application is very infrequently followed in our day to day classrooms. Children need training in handling their irradicideas. This is only possible through experimentation. It is through actions as well as thinking, through actions that the real knowledge is born in the minds of individual children.

In the Essential Piaget, Howard E.Gruber and J.Jacques schematize the following four possible Educational approaches based upon the application of the Piagetian Ideas -

1. Tools - respect for the individual artisan. Abundance of semi-structured instructional and illustrative materials drawn from diverse fields of knowledge.

2. Paris- Pleasures of discussion between equal partners.

3. Athens- as reflected in the socratic method.

4. Eldorado- as reflected in inquiry and discovery methods.

The vision of his work, may it be a case of one sided interpretation, puts aside on the road several of the thinkers usually encountered in educational literature when it comes to the Education of the Head. In this context, what ought to be the main aim of education. To quote Piaget :

" The principal goal of education is to create men who are capable of doing new things, not simply repeating what other generations have done.... men who are creations, inventors and discoverse. The second goal of education is to form minds

which can be critical, can verify, and do not accept everything they are offered. The great danger today is from slogans, collectiv opinions, ready made trends of thought. We have to be able be resist individually, to criticize, to distinguish between what is proven and what is not. So we need pupils who are creative, who learn early to find out by themselves, partly obey their own spontaneous activity and partly through material we set up for them, who learn early to tell what is verifiable and what is simply the first idea to come to them".

In the process of interiorization of knowledge founded on action, Jean Piaget appears to have cut off several joints in the area of cognition by giving each of them an epistemological context within the black box as visualized by the behaviourists between Stimulus and the Response for the benefit of carrying out the needed structural improvements in the teaching-learning process by the practising teachers who may now know how to act decisively when they know how the human mind reacts to concrete and abstract situations at the various levels of intellectual development implying thereby that more and more inputs in education may not lead to more and more astounding results for vice versa may even hold true in the Genevan context. So, in the name of modernization, if any country simply down grades the content, it is bound to generate allergies all around within its borders for the basic Piagetian essence process at the cost of Product is just missing in this scheme. In summary, spin off advantages, await round the corner if one cares to turn one's gaze on the Genevan School so laboriously built imaginatively under the leadership of Professor Jean Piaget.

From this, according to A.Blanchet and others,emerges the finest educational principle meeting diverse individual differences of the growing youngsters :

1. It Must Permit the Child to Establish Plans to Reach Distant Goals, While Leaving him Wide Open Freedom to Follow His Own Routine.
2. The gap between the learning in the classroom and outside of it is closed for parts of the hidden environment open up as naturally as Learning to Walk through the three lines of Access to Knowledge,namely,Perceputal, Acting and Conceptual.
3. The world need no longer pass by as usual for it is the business of the human mind to go on creating novelties, each more noveler than the other, for we do participate in the intellectual race trailed by Einstein,Freud,Chomsky and Piaget, to mention a few in this century.

ADDITIONAL PROBLEM FOR FURTHER RESEARCH

The work of Jean Piaget present several problems in the areas of Physics, Chemistry, Biology, Mathematics and Language development. In his book on the 'Growth of Logical Thinking', he has also shown a research frontier yet to be invented. Before his death, he also hinted at the possibility of the existence of the fifth stage of mental development. So the period empirically covered is about 2 decads. The complex thinking shown by adults in different branches of knowledge is yet to be system-atically attacked.

If few studies so for conducted on intelligence, problem solving and creativity are excluded, there are many problems which needt heir solution in the due course of time. If the developing countries are taken into consideration, problems of formal and non-formal Education in the piagetian context, then, these problems can be more fruitfully attacked. The same ideas can also be tried out on pupils belonging to the weaker sections of society, slim children, illeterate children and sheduled caste as well as schedule tribe children. Pupils of tribal areas can also be studied in the Piagetian context. These studies, if undertaken will definately throw light on the nature of intelligence.

In the context of this study, the growth of experimental minds among different groups of adolescent pupils drawn from every possible strait of society can be tested in the Piagetian context, errors noticed and corresponding remedial possible undertaken at the most appropriate time. So this type of work provides emple of opportunities for developing the psychological structure of every school subject because the work of Piaget provides fruitfull insite into several areas of knowledge as it develop among childrens. Other personality and enviornmental variables can be included. Such studies will bridge in the gap between qualitative investigation andthe quantitiative investigati under taken only in the psychometric context.

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CHAPTER-VI

HUMP-EFFECT ENCOUNTERED INCIDENTLY

CHAPTER VI

ADDITIONAL EVIDENCE ON HUMP EFFECT ENCOUNTERED INCIDENTLY

INTRODUCTION

While studying thinking among adolescent pupils matched along intelligence and grade, Prof.N.Vaidya found that whereas general understanding increases with age, dominant errors that is shared by more than 20% of the pupils suffered, humps in several contexts. This phenomenon was followed up by T.S.Sandhu also during the mastery of thought processes during adolescence in the case of unmatched groups of adolescent pupils. They also searched for additional evidence in the relevant literature and came out with some data not interpreted earlier in that way.

Later on, T.S.Sandhu in his doctoral work also encountered the same phenomenon when it was not the object of direct investigation. Even Prof.J.S.Bruner having similar data at hand, missed the phenomenon and called it the " Growth Errors " To quote J.S.Bruner -

" The type of error that you refer to, which we speak of as growth error, is one in which the growing child tries out a new strategy although it is not well developed and uses it in place of an older one which was been working well. It is errors of this sort which suggest to me the venturesomeness of learning during this early period, the human beings are willing to shift to a less certain and more powerful strategy, before they have it under control, in preference to one which is safe, sound and dull ".

This phenomenon appears according to Vaidya, when the students are at the transitory stage of any two mental stages of development, particularly speaking, concrete and formal stage when the problem are administered individually to the pupils. This is a time consuming process, Using the Questionnaire approach, when the data were further looked into, the present investigator found the similar phenomenon.

1. While stating the number of average hypotheses from grade to grade this phenomena has not appeared in the studies of Vaidya, Sandhu and others, as far as the knowledge of the Investigater goes.

2. Errors committed on the Magic seed problem.

3. Errors committed while formulating questions on Cycle, whose answers the pupil did not know.

4. While engaged in exhausting several combinations as fully as possible provided the resting points which are termed as errors (digit problem).

ILLUSTRATION OF THE PHENOMENON

Selected data involving " Hump Effect " are now presented in respect of thought processes, as follows -

TABLE- 1.1

(STATING OF HYPOTHESES)

S.No. Name of Problem	Mean Scores at different grades.					
	VI	VII	VIII	IX	X	XI
1. Flow of water through a tube.	3.8	4.5	8.1	7.8	6.2	7.8
2. Simple pendulum	4.5	4.6	7.7	8.0	7.5	8.1
3. The Ramp Problem	3.1	3.5	7.0	7.0	6.4	7.2
4. The Seed Problem	5.0	6.1	7.2	8.3	6.7	8.9

Consider now the graphical illustrations of the data presented above.

Fig.No.I

(Hump in the mastery of thought processes on problem No.1).

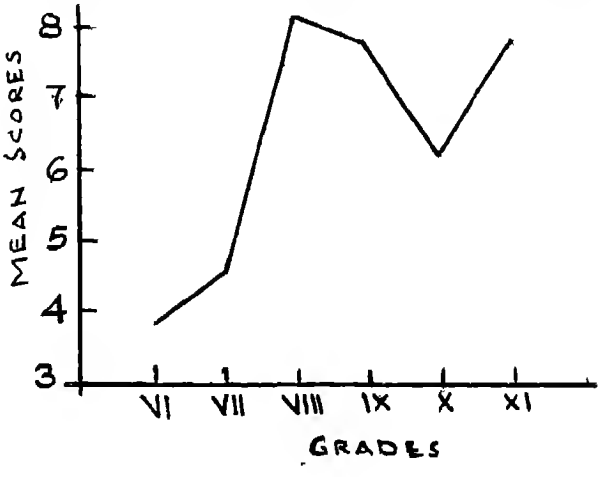
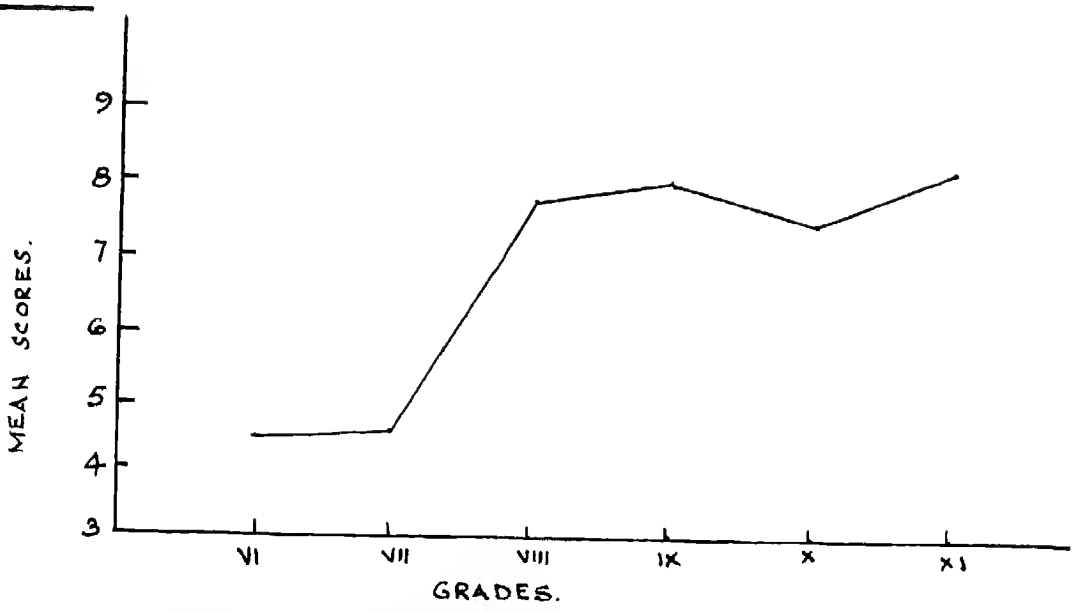
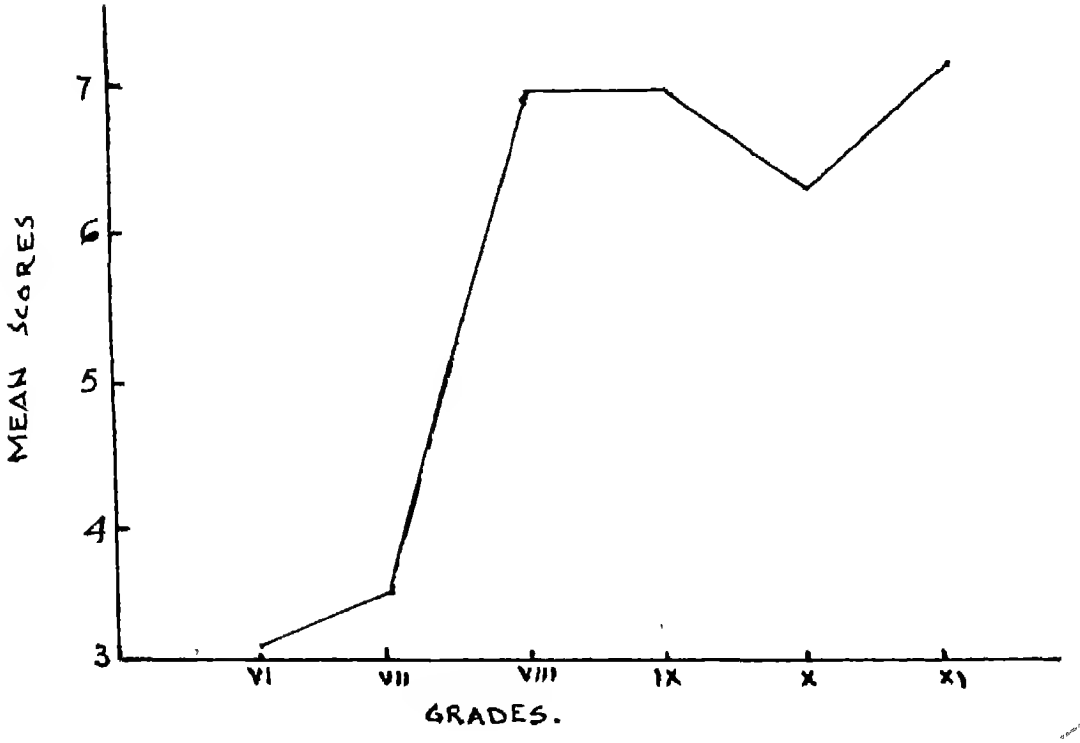


Fig.No.II



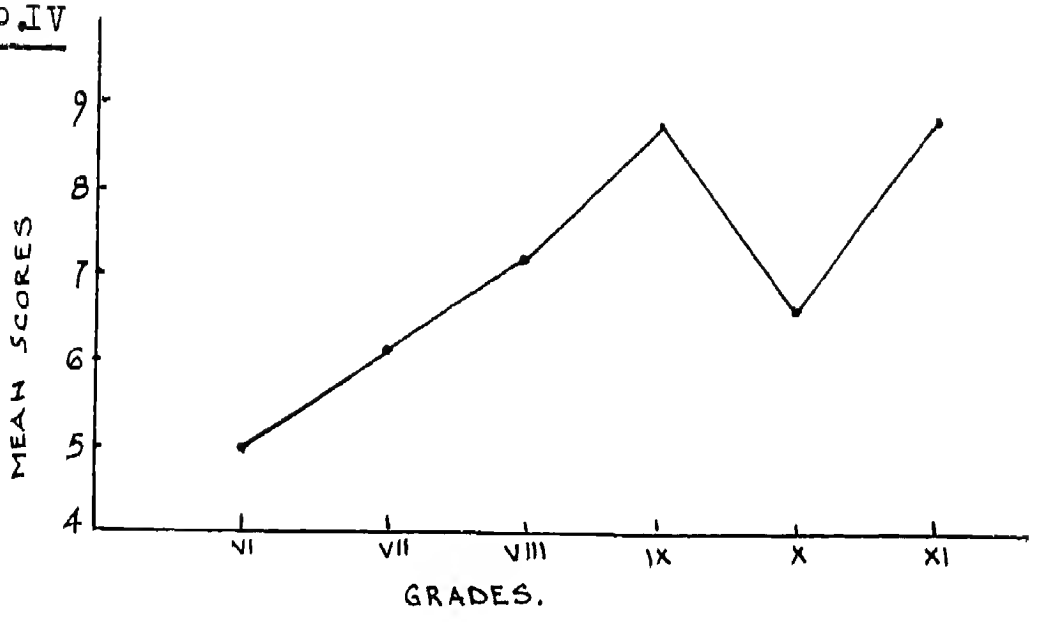
Hump in the Stating of Hypotheses on Problem No.2.

Fig.No.III



Hump in Stating of Hypotheses on Problem No.3 (Fig III)

Fig.No.IV



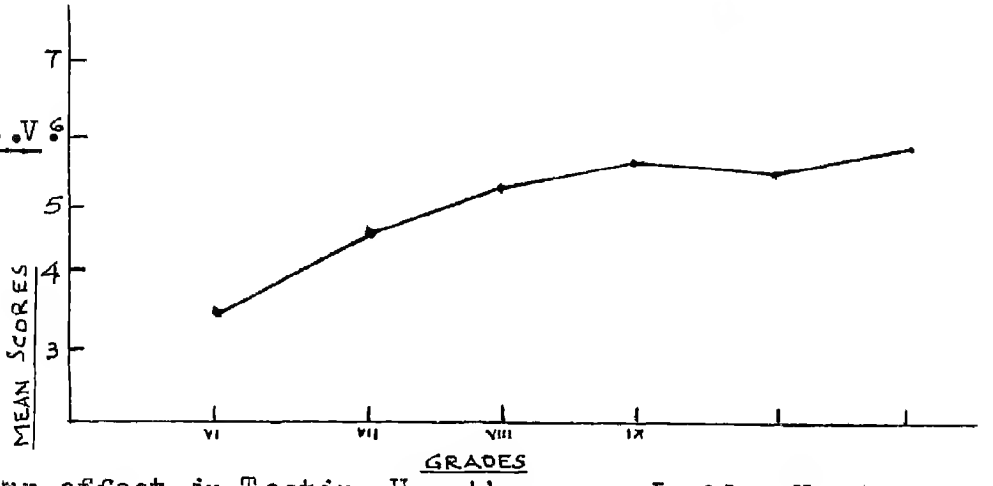
Hump in stating hypotheses on Problem No.4

TABLE NO.1.2

S.No.	Name of Problem	Mean Scores at different grades.					
		VI	VII	VIII	IX	X	XI
1.	Flow of water through a tube.	3.3	4.3	5.0	5.3	5.2	5.5
2.	Simple pendulum Problem	3.4	4.3	3.7	4.9	4.9	5.3
3.	The Ramp Problem	3.5	4.0	3.1	4.6	4.6	4.9

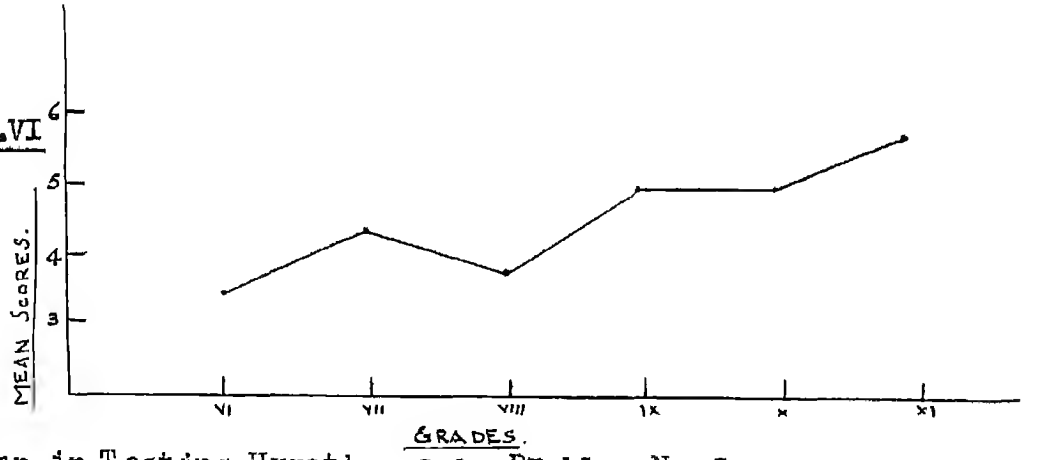
Now consider another set of graphical illustrations. Showing hump effect on Testing of Hypotheses.

Fig.No.V



Hump effect in Testing Hypotheses on Problem No.1

Fig.No.VI



Hump in Testing Hypotheses on Problem No.2

Fig.VII

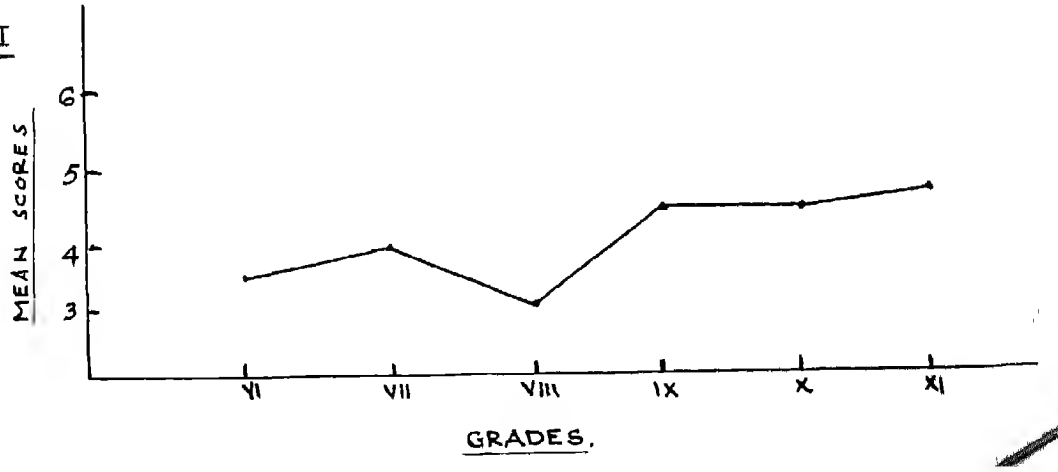
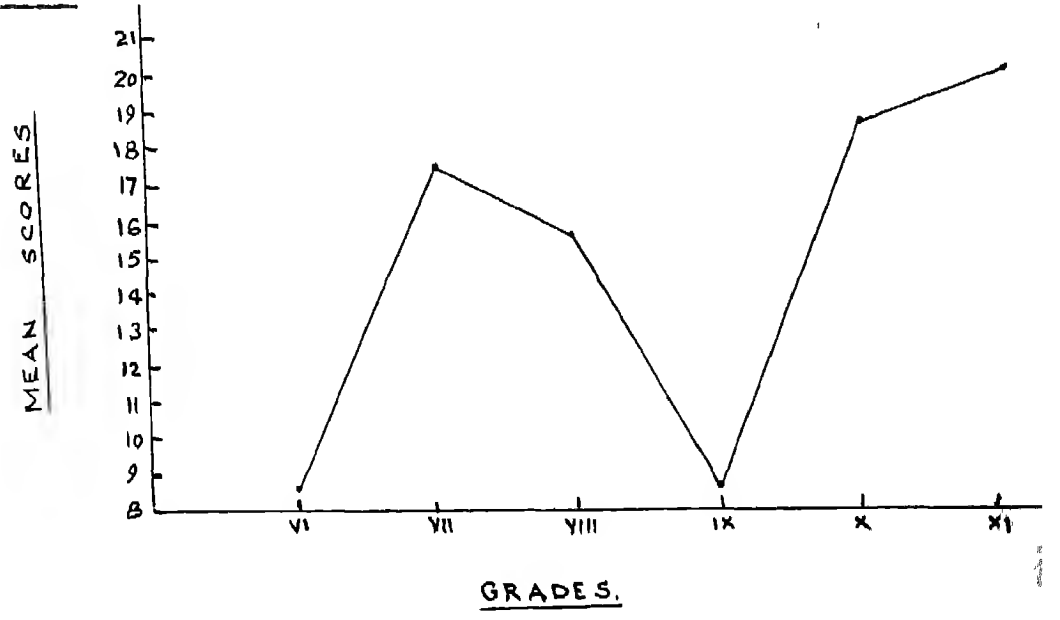


TABLE NO.1.3

S.No.	Name of Problem	Problem number	Mean Scores at different grades.					
			VI	VII	VIII	IX	X	XI
1.	Using 2-digit at a time.	1(a)	8.6	17.4	15.5	8.6	18.5	20.0
2.	Using 3-digit at a time.	1(b)	.60	3.1	4.7	3.1	6.4	9.2
3.	Using 4-digit at a time.	1(c)	6.2	3.6	4.0	8.6	4.2	4.0
4.	Inviting wrong answers	3	3.1	3.6	3.8	3.0	3.1	1.8
5.	Magic Seed Problem	4	10.3	14.2	19.1	18.1	22.7	23.6
6.	Worm Movement Problem	5	3.9	4,5	4.2	4.4	5.0	4.7

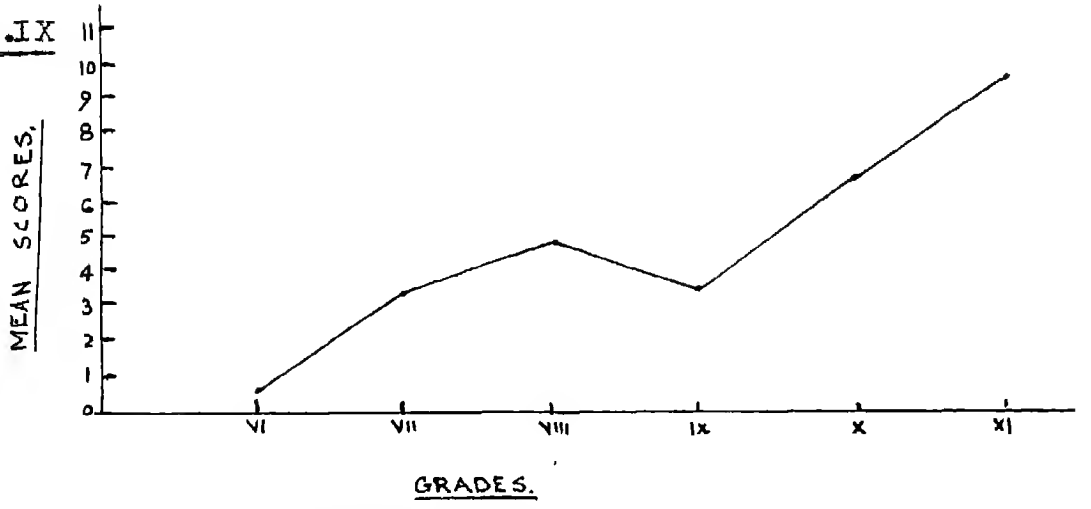
Again we are considering another set of graphical illustrations, showing hump effect on different problems as listed above.

Fig.No.VIII



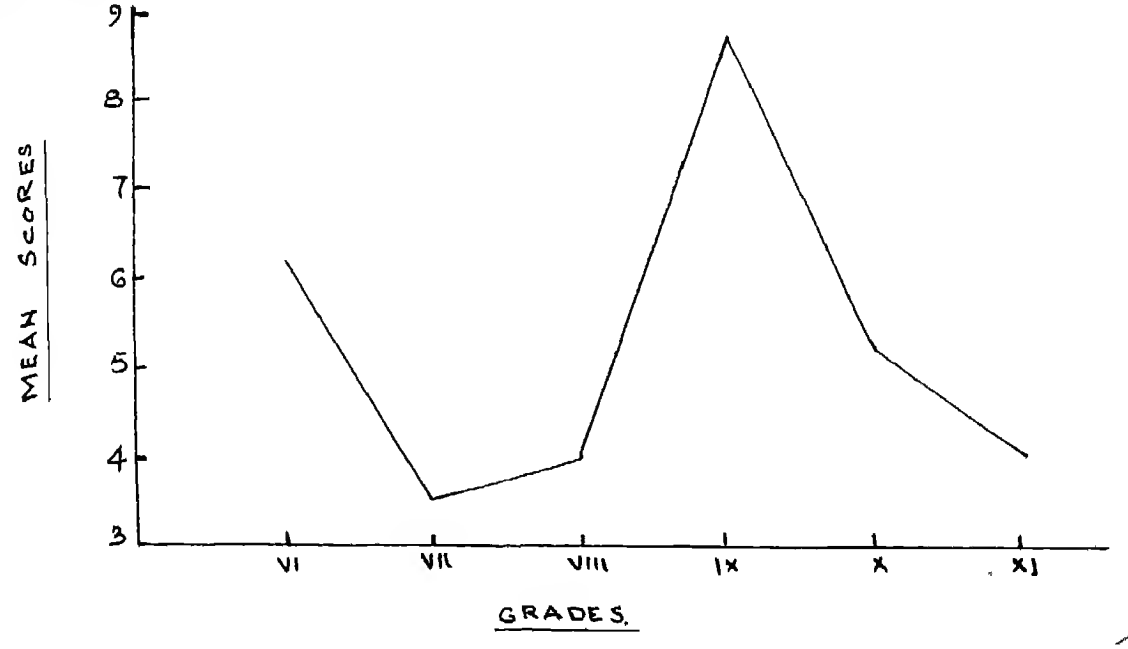
Hump in the combinational problem on digit-problem 1(a)
Using 2-digits at a time.

Fig.No.IX



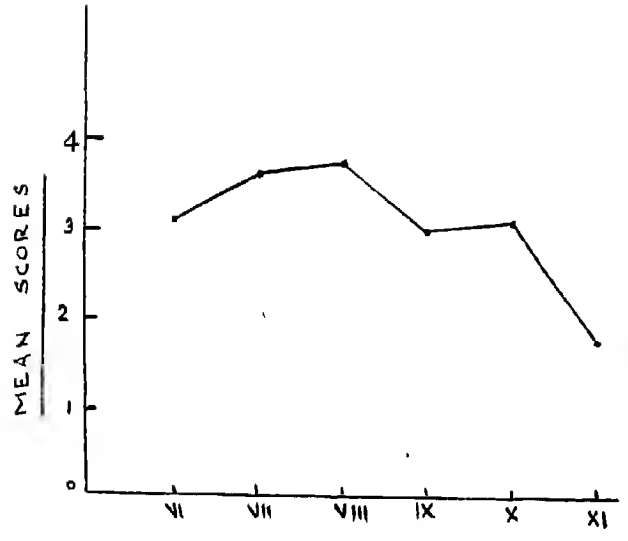
Hump in the combinational digit problem No.1(b),
Using 3-digits at a time.

Fig.No.X.



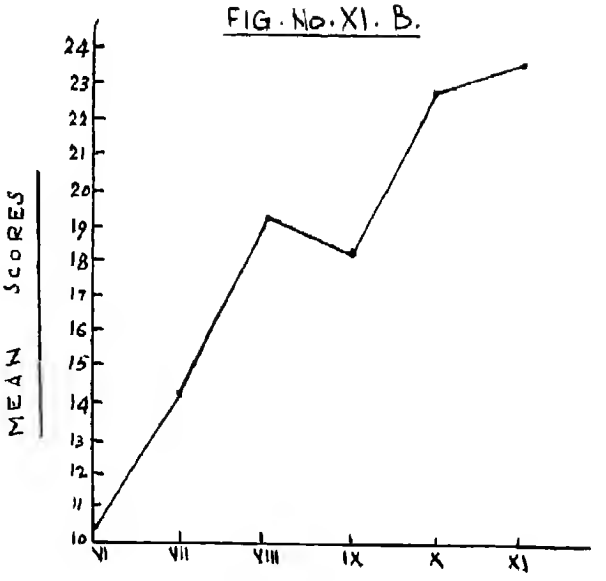
Hump in combinational digit problem No.1(c)
Using 4-digits at a time.

Fig.No.XI. A.



Hump in Magic seed Problem.

FIG. No. XI. B.



Hump in inviting wrong answer

Fig.No.XII

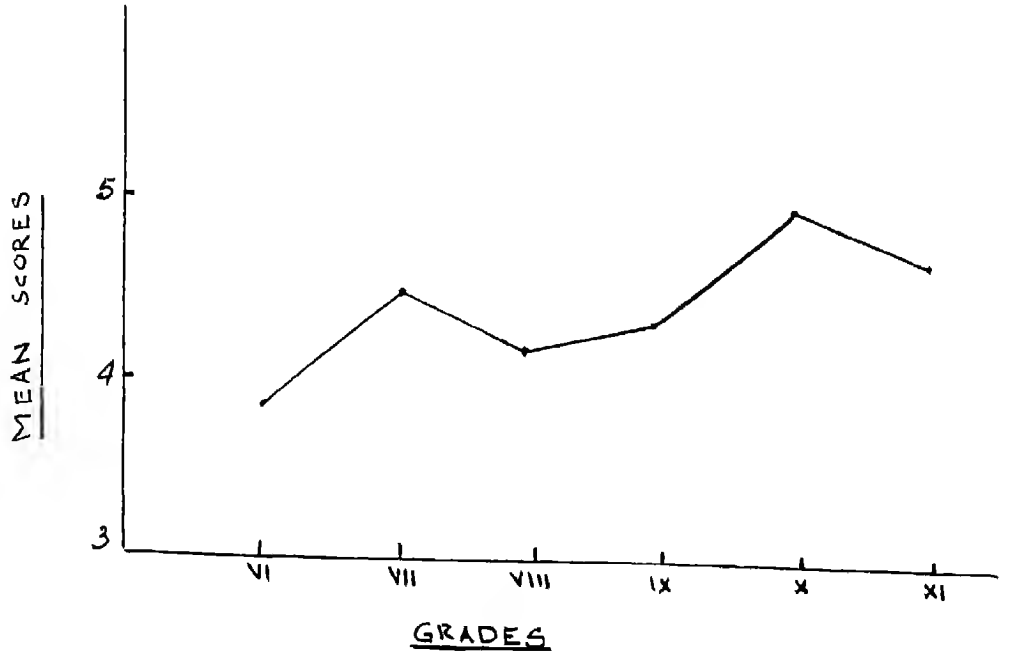


TABLE NO.1.4

S.No.	Name of Problem	Problem number	Grade-wise average of pupils committing errors.					
			VI	VII	VIII	IX	X	XI
1.	Cycle Problem	2	.6	.9	.4	1.0	.5	.8
2.	Magic Seed (resting points)	4	.6	1.8	5.5	3.8	3.5	4.4

Now consider another set of graphical illustration showing hump effect on errors committed in above mentioned problems.

Fig.XIII

Hump of errors committed in Cycle problem.

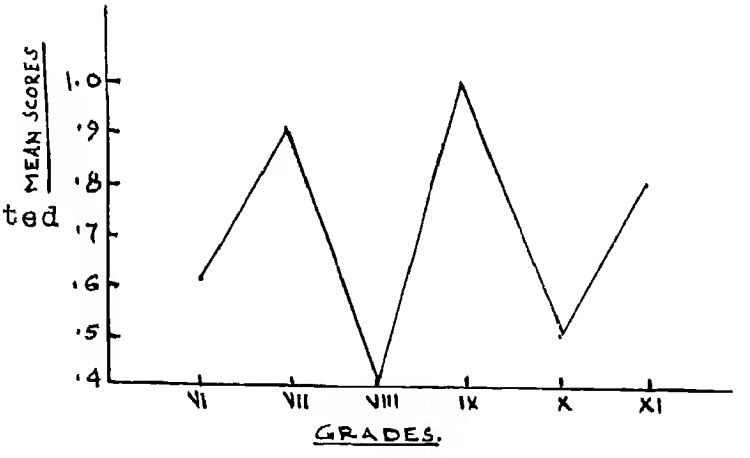
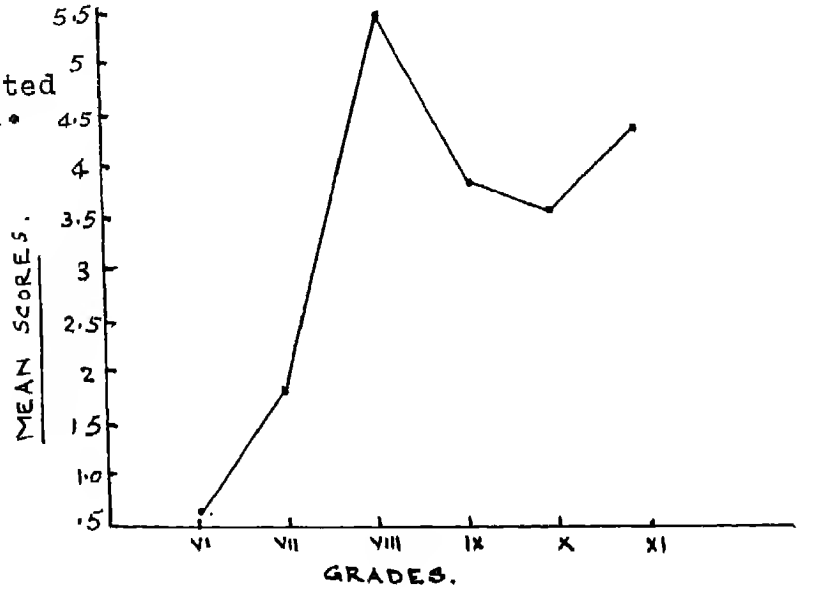


Fig.XIV

Hump of errors committed in Magic seed problem.



ADDITIONAL SUPPORT FROM LITERATURE

The hump-effect encountered incidently in present study, supported by the related studies of piaget and Inhelder (1977), Lovell and Ogilivie (1977) and David Elkind (1977) but they missed referring to it in their studies. Recent studies by vaidya and Sandhu(1978) and Padimini M.S.(1981) further shows strong evidence of the same phenomenon.

Consolidated data in this context, presented in tabular as well as graphical from as follows -

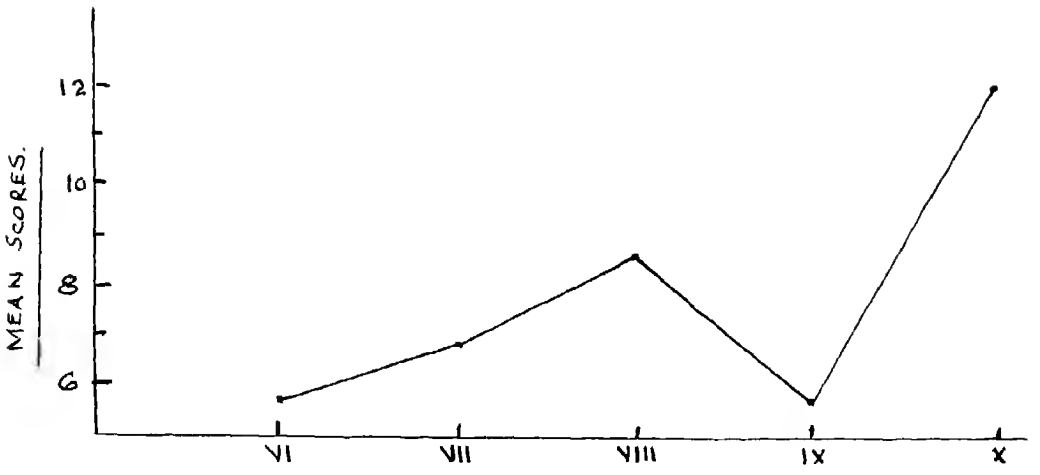
TABLE NO.1

.Showing Mean Performance on Various Problems.

(According to Padmini M.S.)

Name of Problem	VI	VII	VIII	IX	X
1. Stating of hypotheses.	21.8	37.8	38.3	33.5	48.3
2. Testing of hypotheses	6.2	10.7	10.4	14.9	15.3
3. Combinatiorial problem	29.4	35.6	38.0	34.6	40.7
4. Cycle problem	5.7	6.9	8.7	5.7	12.4
5, Resting Points in Combinatorial problem.	11.3	7.9	8.6	4.5	5.5
6. Errors commiting in cycle problem	1.7	1.2	0.8	0.2	0.5
(According to T.S.Sandhu)					
1. Digit Problem	2.67	2.45	5.35	5.40	7.78
2. Formulating questions problem.	5.67	9.13	7.40	9.65	11.48
3. Hypotheses testing	.60	.13	.60	.00	.87

FIG. No. XVIII

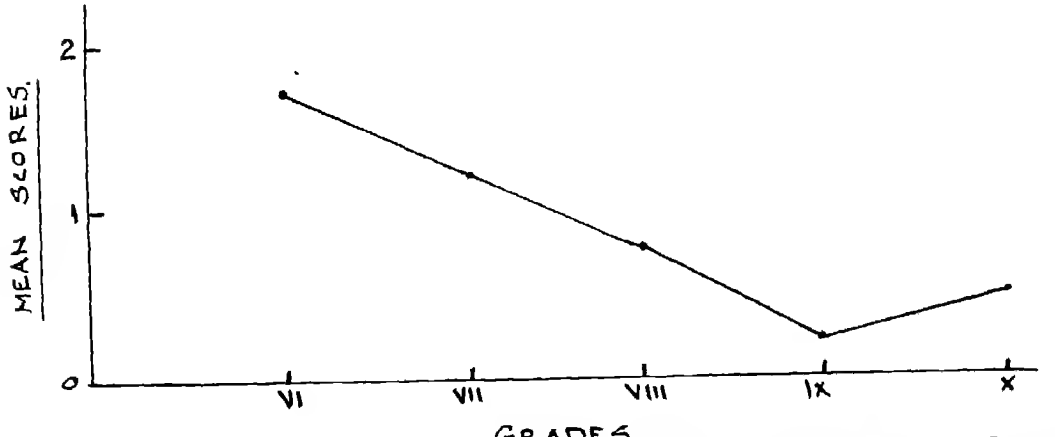


Hump in cycle Problem

FIG. No. XIX

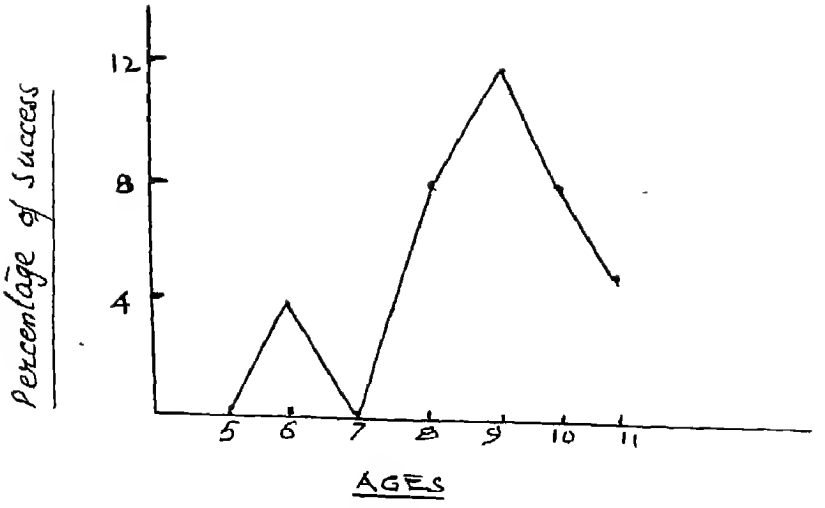
Hump in Resting Points in combinatorial Problem

FIG. No. XX



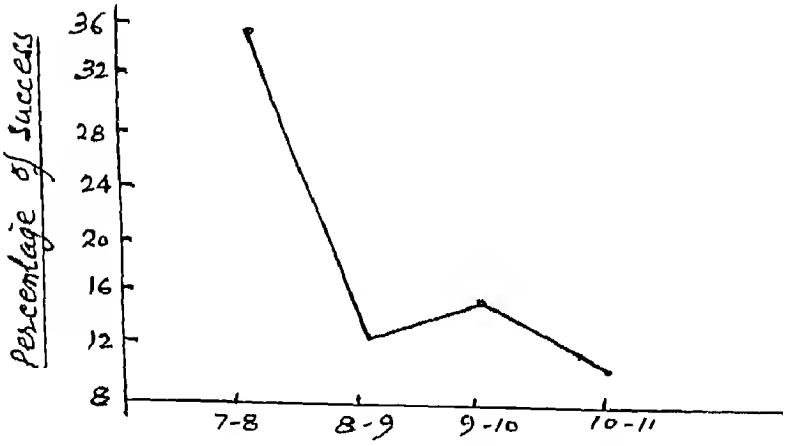
Hump in errors commiting in cycle Problem.

FIG. NO
XXIV



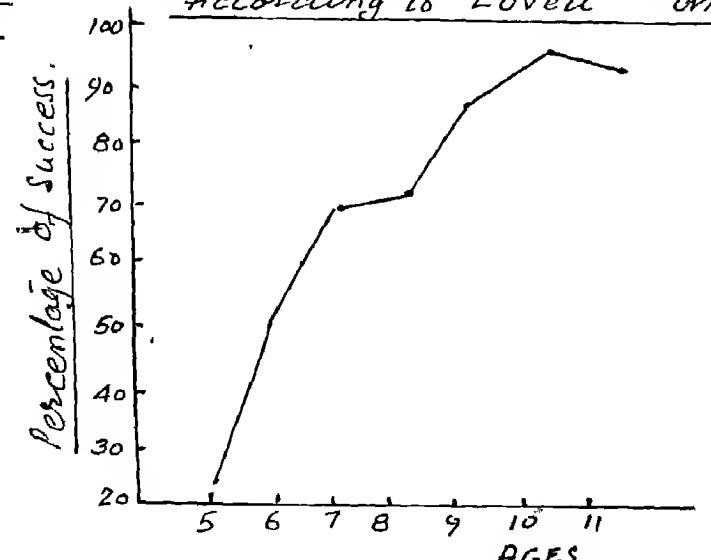
Conservation of weight (transitional)
According to Piaget and Inhelder.

FIG. No
XXV



Conservation of Substance (Transitional)
According to Lovell and Ogilvie.

FIG. No
XXVI



Conservation of Substance
According to David Elkind

CONCLUDING STATEMENT

On balanced it appears that there is either dip in performance or the errors increase and decrease with age before the individual concepts settled down finally. It is here that the mind of the individual lives in the world of possibilities where he may go on committing errors with a view to grasp the basic concept.

At this stage it is not possible to provide any sensible explaination because for pin-pointing this phenomenon it is very-very necessary to know the complete past history of the individual subjects . If this is not done and the groups of pupils are not properly matched on as many as possible variables, this phenomenon may not appear to be clear.

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CHAPTER VII

SUMMARY AND CONCLUSIONS

CHAPTER- VII

SUMMARY AND CONCLUSIONS

INTRODUCTION

The work of Jean Piaget is receiving world wide attention. A fundamental idea that underlies all of Piagets work and and consequently the key to understanding his theory, is the concept of mental structure . Basically, mental structures are hypothesized ' mental blue-prints ', that guide the organisms behaviour. In the course of intellectual development from infancy to childhood, these mental structure are constructed and re-constructed within the brain and this construction of mental structure is viewed by Piaget as the fundamental process in intellectual development.

Piaget has described the intellectual development of children as a series of consecutive stages which, in turn, are dependent upon each other. In Piaget's terms, a stage is

identified not by quantitative measurement but by qualitative characteristics.

To explain all these developmental stages from ch-ild hood to late adolescence, Piaget used the term 'Operation'. According to him- An operation is the essence of knowledge; it is an interiorized action which modifies the object of knowledge. It is always linked to other operations, and as a result it is always a part of a total structure. Piaget considers these operational structure as the basis of knowledge and distinguish four main stages of development, namely- sensory motor stage, Pre-operational state, Comcrete Operational Stage and Formal Operational Stage.

PROBLEM RESTATED

The problem was stated as :

" GROWTH OF EXPERIMENTAL MIND DURING ADOLESCENCE "

PURPOSE OF THE STUDY

The purpose of the study was to -

(i) To see how processes of thinking take place in adolescent people on certain selected science concepts.

(ii) To determine the Relationship between stating of hypotheses and achievement in science.

(iii) To determine the Relationship between testing of hypotheses and achievement in science.

(iv) To determine the relationship between stating of hypotheses and testing of hypotheses.

(v) To explore the hump effect, if encountered incedently.

HYPOTHESES

The present study proposes the following Hypotheses -

(i) There is no significance relationship between the following variables -

a) Total score of stating of hypotheses and achievement in science.

b) Total score of testing of hypotheses and achievement in science.

c) Total score of digit problem and achievement in science.

d) Total score of magic seed problem and achievement in science.

e) Total score of stating of hypotheses and testing of hypotheses.

(ii) There is no significant relationship in the scores on the processes of thought all taken together, problem-wise and total individual problemwise from grade to grade.

(iii) There is no difference between the top group and bottom group on -

a) Stating of hypotheses.

b) Testing of hypotheses.

JUSTIFICATION OF THE PROBLEM -

The schemes of thought as propounded by Jean Piaget have been loosly worded. With the possible exception of the scheme of thought: Prepartion, very little work has been done in area on scheme of thought during adolescence. The same is true of

stating and testing hypotheses (proposition) these two variables were examined separately by N.Vaidya in his book- " The Growth of Logical Thinking in Science during Adolescence ".

As usual, he also used only one problem namely, the flow of water through a glass tube. It had always been the concern of Prof.Piaget that a given scheme of thought should be studied in its maximal variation. So study was needed where the scheme of thought relative to the stating and testing of the hypotheses across the problem could be studied on the same sample and hence, justification of problem.

PLAN AND PROCEDURE -

The sample for the prescne study constituted of 120 pupils, twenty each from grade VI to XI of Demonstration Multipurpose School,Ajmer. The age range of students were from 11^{+} to 16^{+} .

SELECTION OF TOOLS -

The following tools were used which aimed at testing-

(i) Stating of Hypotheses

(ii) Testing of Hypotheses

(iii) Understanding of some interesting and funny questions.

All the three are in the form of questionnaire.

ADMINISTRATION AND SCORING OF THE THREE DIFFERENT QUESTIONNAIRES USED -

The administration was done to the sample selected in their respective classes. The experiments on different problems were set

and explained to the students by the investigator herself. The subjects were asked to observe the experiments and write down the different hypotheses on the problem presented. The time taken to state the hypotheses ranged from 30 minutes to 45 minutes.

Similarly second and third questionnaire were distributed and subjects were asked to test the hypotheses given in the problem. The time taken ranged from 30 minutes to 50 minutes. Scoring was done on stating of hypotheses by listed down all the hypotheses given by subjects. The number of hypotheses given by each pupil was also scored. The total number of wrong hypotheses for each problem were also recorded and then the co-efficient of fluctuations. Similar scoring was done on testing of hypotheses and some interesting problem questionnaire.

RELATED PAST WORK -

Very little work within the context of the study has been attempted so far. However, chronologically speaking, workers like Inhelder,B.and Piaget,J.(1958), Wheeler,D.(1958), Lovell,K.(1961), Mealings,R.(1961), Burner,J.S.Goodnew and Austin (1962), Vaidya,N.(1964), Farrell,M.A.(1969),Ginsburg, M.and Opper,S.(1969), Higgings,T.A.and Gaite,A.J.H.(1971), Howe,A.(1974), Lawson(1974), Joyce,L.K.(1977),Lius,L.canta and J.Dudley Herren,(1978), Pandey,K.C.(1979), Sandhu (1979), Vaidya(1980), Padmini (1981) etc., have attacked this problem in its varying context. Their work when seen together shows the following patterns of finding -

(i) The concrete operational stage is quite dominant among normal adolescent pupils.

(ii) Whereas the adolescent pupils are in a position to state hypotheses, they are not in a position to test them. At best they can test one variable or so in most of the case.

(iii) The attack on problem is seen to increase systematically with increasing grade as well as age.

(iv) It is possible to identify concrete and formal operational pupils through cluster analysis.

(v) The study of physics need more formal thought then chemistry and biology.

(vi) Mental age and grade are the two important factors then chronological age in concept development.

(vii) There appears to be significant relationship between scores on formal operational thought on the one hand and achievement as well as creativity on the other.

MAIN FINDINGS - These indicated :

(i) The mean performance on stating of hypotheses, Testing of hypotheses and some interesting and funny question shows a strong increasing trend with grade.

(ii) Interest of child in solving problems increases with grade .This shows capacity of grasping the problem also increases with age and grade.

(iii) There is a dip in means, within the over all growth in some of the grades in stating the hypotheses, testing

of hypotheses and some interesting questions. Hump-effect is hinted at.

(iv) There is significant correlation between total Piagetian tasks and the achievement in science at .01 level of significance.

(v) There is either dip in performance or the errors increase and decrease with age before the individual concepts settled down finally.

(vi) The questions intentionally inviting wrong answers were attracted a large number of errors, again there are possibilities of hump effect.

(vii) Sometimes, it appears that adolescent pupil influenced by the content rather than the form of the problem. It is commonly appeared in the pupils studying in lowwr grades.

(viii) On worm problem, 24%, 30%, 42%, 42%, 72% pupils from grade VII to XI respectively suggest experiment for their explaination to the solution of the problem. This finding shows that not a single people from grade VI was able to suggest experiment. However in grade XI 60% of pupils were in a position to suggest additional experiment and 40% of the same grade were not in position to suggest experiment.

(ix) On combinatorial, Magic seed problem, the pupils give more than 75% of combinations were found to be 5, 12, 15, 16, 20, 20 respectively from grade VI to XI. Similarly in digit problem , pupils give more than 75% of the combination, their score ranged from 7, 16, 13, 7, to 18 and 20 respectively. which shows that pupils of class VI were not in a position to exhaust all possibilities.

(x) Hump effect is suspected strongly on the variable of stating of hypotheses, earlier missed by Sandhu and Vaidya.

ADDITIONAL PROBLEM FOR FURTHER RESEARCH -

Additional problems for research as well as the various educational implication arising out of the studies have been pointed out within the text of this thesis.

DELIMITATIONS

The sample drawn was from one local city school having english medium and of average soci-economic group.

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APÊNDICES

3. Is any other experiment necessary ? If yes, suggest the experiment with diagram.

Now, answer the following questions (Just tick-mark, whichever alternative i. e., Yes/a bit/No as applicable to you)

S. No	Questions	Yes	a bit	No
1.	Have you done a problem of this type before ?			
2.	Did you find the problem difficult to solve ?			
3.	Did you find the problem interesting ?			

RAW SCORES

(120 Pupils)

S.No.	1	2	3	4	5	6	7	8	9	10	11
1.	P1	22	16	28	22	9	12	1	1	7	2
2.	P2	25	18	23	14	9	11	1	1	3	2
3.	P3	23	28	24	24	9	13	1	2	7	3
4.	P4	11	18	29	22	13	35	3	3	5	3
5.	P5	21	20	27	17	11	12	4	0	13	4
6.	P6	18	18	22	21	7	10	1	1	11	5
7.	P7	26	35	32	10	8	23	4	1	14	5
8.	P8	27	24	26	27	14	14	1	2	14	3
9.	P9	28	38	25	9	11	15	1	1	7	2
10.	P10	26	36	24	14	14	19	1	1	10	6
11.	P11	13	10	10	18	8	2	8	2	14	4
12.	P12	27	22	23	15	13	16	6	1	9	4
13.	P13	18	35	26	13	12	11	6	1	18	4
14.	P14	18	13	20	9	11	23	2	2	7	3
15.	P15	21	10	29	14	15	8	1	1	12	2
16.	P16	11	14	18	17	12	10	1	2	17	4
17.	P17	13	13	7	15	4	12	3	1	7	7
18.	P18	28	18	26	22	9	10	1	0	10	4
19.	P19	18	20	13	11	7	6	1	0	8	6
20.	P20	25	18	19	12	9	8	2	0	13	6
21.	P21	21	41	32	17	15	21	4	0	8	3
22.	P22	27	24	20	12	12	21	4	0	13	3
23.	P23	24	35	34	25	10	13	1	1	7	4
24.	P24	25	26	26	11	9	44	5	2	11	5
25.	P25	18	22	22	15	11	18	1	0	17	4

S.No.	1	2	3	4	5	6	7	8	9	10	11
26.	P26	24	23	25	20	13	12	3	0	6	6
27.	P27	36	30	36	22	14	21	1	2	20	4
28.	P28	20	12	29	20	9	24	2	0	6	3
29.	P29	12	18	22	19	13	12	2	2	18	3
30.	P30	22	24	19	21	12	22	1	2	24	5
31.	P31	23	34	23	16	17	19	4	0	13	3
32.	P32	25	31	36	22	18	19	1	1	6	6
33.	P33	18	19	36	23	14	27	2	0	11	4
34.	P34	19	18	20	17	11	17	5	2	15	4
35.	P35	10	29	23	6	12	19	3	0	10	6
36.	P36	20	28	19	20	12	12	2	4	19	5
37.	P37	30	30	37	21	9	12	5	3	17	4
38.	P38	11	26	18	22	15	10	1	3	19	3
39.	P39	23	19	26	19	13	12	4	1	12	3
40.	P40	16	18	32	19	13	17	4	3	24	3
41.	P41	21	45	29	27	10	23	3	2	24	4
42.	P42	27	19	11	24	17	21	5	2	15	4
43.	P43	24	36	30	37	15	15	6	1	7	4
44.	P44	25	37	37	21	7	13	3	2	25	5
45.	P45	18	19	18	27	12	27	4	2	20	7
46.	P46	24	49	31	40	14	22	4	1	23	4
47.	P47	36	45	38	31	11	27	3	3	19	5
48.	P48	32	36	25	23	13	20	3	1	7	1
49.	P49	14	13	15	21	10	3	1	3	18	7
50.	P50	15	20	21	24	16	19	2	1	20	6

S.No.	1	2	3	4	5	6	7	8	9	10	11
51.	P51	25	35	28	26	11	11	4	1	20	4
52.	P52	13	24	18	47	7	26	3	2	9	4
53.	P53	10	26	12	42	12	19	6	2	21	3
54.	P54	9	29	16	28	12	25	9	1	22	2
55.	P55	13	32	30	37	14	28	3	3	17	3
56	P56	32	30	34	25	14	25	4	1	20	4
57.	P57	22	31	12	31	12	20	5	1	22	3
58.	P58	16	34	21	32	9	24	5	2	25	2
59.	P59	31	45	35	24	10	12	2	0	24	6
60.	P60	36	43	32	30	14	18	6	2	25	6
61.	P61	27	33	31	27	11	5	3	1	24	6
62.	P62	28	18	22	29	24	26	3	5	29	5
63.	P63	43	41	26	46	16	18	10	5	23	3
64.	P64	28	21	23	19	18	20	3	3	21	5
65.	P65	7	7	14	24	14	15	6	2	13	6
66.	P66	26	26	19	35	16	16	8	3	14	4
67.	P67	35	49	36	19	18	24	8	1	9	2
68.	P68	26	27	21	39	13	33	8	1	25	4
69.	P69	15	10	12	38	8	13	8	2	8	5
70.	P70	28	22	16	34	12	21	6	3	11	2
71.	P71	36	39	29	22	15	21	6	2	20	5
72.	P72	43	38	33	36	17	12	2	3	14	6
73.	P73	22	12	9	29	14	23	2	3	29	4
74.	P74	19	18	11	41	18	24	1	4	19	4
75.	P75	23	24	18	39	19	17	4	3	14	5

S.No.	1	2	3	4	5	6	7	8	9	10	11
76.	P76	18	18	15	26	20	21	4	1	15	3
77	P77	37	11	28	26	8	24	1	3	23	4
78	P78	26	21	20	28	7	24	1	1	5	3
79	P79	21	18	17	39	19	22	2	3	24	7
80	P80	32	27	34	28	22	16	4	2	24	5
81	P81	25	26	22	29	13	25	2	3	18	2
82	P82	19	41	25	33	20	46	2	5	22	4
83	P83	43	22	16	24	15	38	1	0	25	6
84.	P84	40	46	25	31	12	31	1	0	27	5
85	P85	25	36	22	34	17	28	1	1	22	4
86	P86	20	39	15	27	11	22	1	4	26	4
87	P87	15	27	16	16	12	12	4	6	20	7
88	P88	44	46	30	21	14	22	1	0	26	4
89.	P89	33	43	26	25	17	28	2	1	25	3
90.	P90	39	24	17	27	20	23	4	2	20	6
91	P91	44	39	26	20	12	22	1	2	24	8
92	P92	13	23	7	33	11	26	2	23	6	6
93	P93	34	19	20	36	11	33	12	2	23	5
94	P94	25	24	20	37	16	29	8	0	20	6
95	P95	33	36	9	24	24	22	4	0	21	4
96	P96	21	19	14	20	15	21	10	3	27	7
97	P97	27	21	16	35	14	23	4	4	22	6
98	P98	39	27	15	16	15	33	2	5	21	5
99	P99	43	46	30	25	9	12	4	3	25	4
100	P100	38	13	16	27	17	29	4	0	10	4

S.No.	1	2	3	4	5	6	7	8	9	10	11
101	P101	23	30	37	27	23	31	8	2	17	3
102	P102	26	35	25	27	14	20	8	1	23	7
103	P103	16	25	20	26	14	18	8	5	25	5
104	P104	16	24	16	35	12	34	8	2	21	3
105	P105	26	19	19	28	38	6	6	6	25	5
106	P106	20	20	23	47	18	28	4	4	26	6
107	P107	29	40	31	23	22	34	10	2	22	3
108	P108	18	19	28	32	15	39	3	5	29	3
109	P109	18	18	17	28	15	18	8	6	25	6
110	P110	23	33	36	28	17	61	8	6	18	6
111	P111	25	32	25	55	14	26	9	6	23	6
112	P112	21	31	31	31	10	23	6	4	21	5
113	P113	22	23	19	39	16	26	8	2	30	6
114	P114	24	21	13	58	15	30	6	6	16	3
115	P115	29	17	25	31	18	39	3	6	23	4
116	P116	15	24	23	27	21	20	12	2	22	4
117	P117	25	24	29	29	15	16	4	4	23	4
118	P118	32	44	43	25	19	23	7	2	23	5
119	P119	24	16	17	33	18	21	7	5	13	7
120	P120	26	19	32	19	25	6	5	30	4	4

ABBREVIATIONS - 1. P - Pupil
2. Achievement in Science English.
3. Achievement in Maths.
4. Achievement in Science
5. Scores on stating of hypotheses.
6. Scores on testing of hypotheses.
7. Scores on digit problem
8. Scores on cycle problem.
9. Scores on inviting wrong answers.
10. Scores on magic seed problem.
11. Scores on worm problem.